Santa Clara Valley
Water District

Final
Engineer's Report

Matadero/Barron Creeks Long-Term Remediation Project

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SANTA CLARA VALLEY WATER DISTRICT
MATADERO/BARRON CREEKS LONG-TERM REMEDIATION PLANNING STUDY
FINAL ENGINEER'S REPORT
PROJECT NO. 102109

Final Engineer's Report Prepared by Schaaf & Wheeler under the Direction of

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October 2002

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SANTA CLARA VALLEY WATER DISTRICT
MATADERO/BARRON CREEKS LONG-TERM REMEDIATION PLANNING STUDY
FINAL ENGINEER'S REPORT
PROJECT NO. 102109

Final Engineer's Report Prepared by

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October 18, 2002

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CHAPTER 1
SUMMARY

STUDY OVERVIEW

In 1997, the Santa Clara Valley Water District (District) completed a series of flood protection improvements on Matadero and Barron Creeks in Palo Alto, California. While these improvements were intended to provide flood protection meeting National Flood Insurance Program standards, subsequent analyses and system performance during the February 1998 El Niño flood demonstrated that the completed improvements do not provide flood protection meeting national standards.

Consequently, the District has elected to undertake a long-term remediation project to bring the flood protection provided by Matadero and Barron Creeks up to standards set forth by the Federal Emergency Management Agency (FEMA), and reduce the burden of flood insurance purchases within Palo Alto. The engineering planning study for this work began in March 1999.

This Engineer's Report presents existing flood problems within the Matadero Creek and Barron Creek watersheds, formulates alternative solutions to those problems, and provides a rationale for the selection of a recommended capital improvement program. Environmental impacts and mitigation requirements for project alternatives are also discussed. (The proposed project Environmental Impact Report (EIR), which is bound with this report, contains a more detailed discussion of environmental impacts and mitigation.)

This document is intended to provide readers with an understanding of current flood protection problems within the Matadero and Barron Creek watersheds, show how the recommended remediation plan has been selected from a number of alternatives, and provide the District's Board of Directors and the public with information necessary to make informed choices regarding the proposed remediation plan and its alternatives.

FLOOD DAMAGE REDUCTION OBJECTIVES

One of the District's stated goals is to provide protection against flooding in a manner that maintains the desired quality of life in a community. This goal is met through a series of flood damage reduction objectives that direct the District's activities:

- Provide flood protection by management of the natural floodplain, or of a modified floodplain, using the more structural types of channel modification only where other measures are impractical.

- Give priority to protection against flooding of developed areas, with the areas of greatest potential damage having the highest priorities.
- Encourage proper controls to prevent incompatible land uses in areas subject to flooding.
- Discourage future land use practices which will subject existing urban areas to additional flooding.
- Ensure that channel modification measures taken to assist an area does not induce flooding upon any other area.
- Maintain District facilities to ensure that they continue to provide the level of flood protection for which they were constructed, both to protect the public's investment and to comply with regulations of the federal flood insurance program.

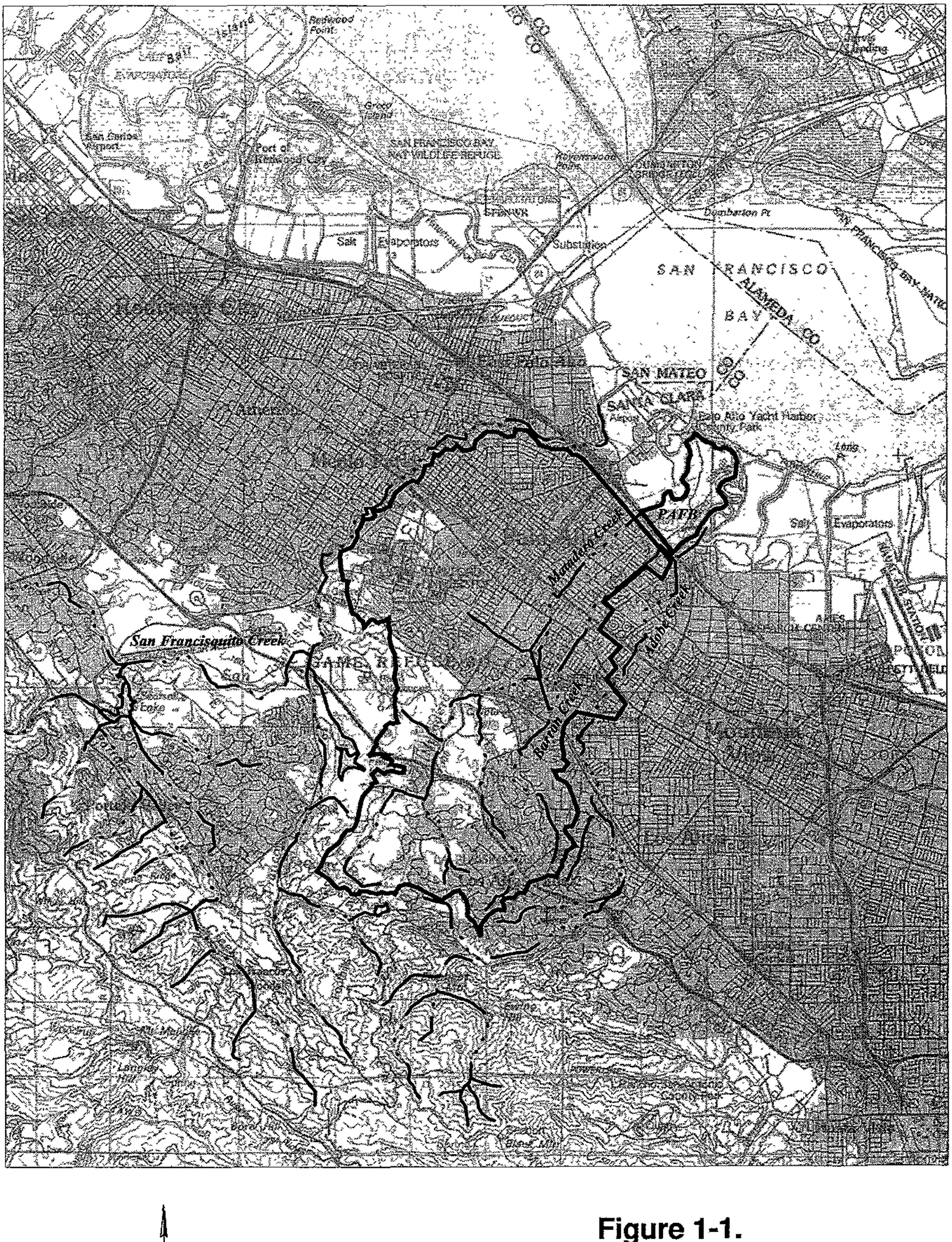
BACKGROUND

Matadero Creek and Barron Creek drain 15.9 square miles and 3.2 square miles, respectively, of tributary watershed into the Palo Alto Flood Basin (Figure 1-1). The watersheds are located in the city limits of Palo Alto and Los Altos Hills, and in unincorporated Santa Clara County.

Historic Flooding

At the turn of the last century, creeks drained the eastern slope of the Santa Cruz Mountains directly to San Francisco Bay through bayland sloughs. By the time those creeks reached the Southern Pacific Railroad, the runoff they carried would overflow the incised channels eventually finding their way to San Francisco Bay via shallow overland flooding.

Significant flooding events in 1940, 1955, and 1958 demonstrated the need for flood control protection to this growing area of Palo Alto. Area property values increased as agricultural land converted to residential, commercial and industrial uses; flood damages experienced during the 1950s led to a series of flood protection projects beginning with the creation of the Palo Alto Flood Basin (PAFB) in 1956. To provide additional flood flow conveyance, the Matadero Creek channel was concrete-lined from Alma Street to Greer Road following the 1955 flood. Land subsidence resulting from groundwater overdrafting from 1920 to 1970 led to a reduction in flood flow conveyance for Matadero Creek, so levees and floodwalls were built in 1971 along stream banks in the area to compensate for the subsidence and contain flood waters in the channels.



SCALE: 1" = 10,000'

Figure 1-1.
MATADERO & BARRON CREEKS WATERSHED LOCATION MAP

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Flood Insurance Study Published in 1980

A Flood Insurance Rate Map (FIRM), first published February 15, 1980 for the National Flood Insurance Program (NFIP), presented the actuarial flood risk situation in Palo Alto. (Within the planning study area, the currently effective FIRM of June 2, 1999 is nearly identical to the map published in 1980.) Tidal flooding is shown from the Bay inland to about Ross Road. Channel constrictions at the Southern Pacific Railroad and El Camino Real caused ponding upstream, but prevented overtopping of Matadero Creek or Barron Creek further downstream.

Recent Flood Protection Projects

A planning study prepared by the District in April 1988 proposed to provide 100-year flood protection to all properties influenced by flooding on Matadero or Barron Creek other than those within the established tidal zone, or those affected by San Francisquito Creek flooding. Recommended projects, with the exception of improvements to Matadero Creek between Hillview Avenue and Foothill Expressway, were completed by 1997 and involved:

1) Additional floodwalls along the existing concrete-lined Matadero Creek channel;

2) Bridge replacements over Matadero Creek at Greer Road, Louis Road, Ross Road, Middlefield Road, Cowper Street, and Waverley Street, the Southern Pacific Railroad, Park Boulevard, Lambert Street, and El Camino Real;

3) Realigned and enlarged Matadero Creek channel between Alma Street and Park Blvd.;

4) Replacement of the trapezoidal channel with 25-foot wide rectangular "U-frame" channel along Matadero Creek between Park Boulevard and El Camino Real;

5) High flow underground bypass channel for Matadero Creek flows from the old railroad bridge at the upstream end of Bol Park to El Camino Real;

6) A high flow underground diversion from the Barron Creek sedimentation basin near Gunn High School to Matadero Creek at Bol Park. This facility diverts sufficient flow so that the Barron Creek channel can adequately pass the one-percent discharge from Gunn to its confluence with Adobe Creek; and

7) A floodwall along Barron Creek upstream from the sedimentation basin.

PROBLEM DEFINITION

Flood protection improvements completed in 1997 were designed to provide conveyance for the one-percent flood on Matadero and Barron Creeks, meeting NFIP standards for freeboard where applicable. That project was not intended to remove mapped flood hazards within the one-percent tidal zone.

While preparing a LOMR application to FEMA subsequent to the completion of the facilities recommended by the 1988 Engineer's Report, however, the District discovered errors in their hydraulic analyses. As a result, the completed project provided increased flood protection, but did not meet current FEMA or District freeboard standards. Several reasons for this have been suggested by District staff and independent review during the present planning effort:

- Design freeboard is one foot less than current FEMA and District standards;
- Design starting water surface elevations were underestimated;
- Channel capacity downstream from Highway 101 was overestimated;
- Hydraulic assumptions used for bridge design were not valid; and
- Certain assumptions regarding the design flow regime were not valid.

Performance During the February 1998 El Niño Storm Event

In November 1997, District officials developed a temporary emergency operations plan to balance flood protection between Matadero and Barron Creeks during high-flow events. This plan reduced the design diversions from Barron Creek to Matadero Creek by 50 percent, but allowed District staff to manually control flows so that some Barron Creek floodwater can be diverted to Matadero Creek when it is safe to do so during large runoff events. This temporary remedy was tested during the February 2-3, 1998 storm event, which produced the highest runoff recorded to date on Matadero Creek. By physically operating the Barron Diversion, District crews were able to prevent overflows along both creeks during the hours of peak storm runoff.

A combination of operational timing and storm duration resulted in Matadero Creek conveying close to the design peak discharge without spilling. However, had District crews not closed off part of the Barron Diversion at a certain point, more flow would have entered Matadero Creek and could have resulted in significant spills along the floodwalls or at bridge crossings. Sufficient freeboard to meet FEMA standards was clearly not provided downstream of Alma Street.

Identified Problem Areas

Once the full Barron Diversion flow to Matadero Creek is restored, protection against the one-percent flood on Barron Creek can be provided in all areas outside of the previously identified tidal zone. On Matadero Creek, however, several problem areas have been identified.

Palo Alto Flood Basin Operation. Higher than anticipated water levels during the February 1998 runoff event prompted a detailed analysis of Palo Alto Flood Basin (PAFB) operation. This storage facility protects lower elevations of Palo Alto against tidal flooding by storing creek runoff during high tides and releasing that stored water on ebb tide through a series of one-way gates. Several factors influence flood basin behavior:

- During significant storm runoff events, climatological factors tend to result in recorded tide elevations that are higher than predicted astronomic tides. Recorded tides during extreme runoff events also tend to be higher than the tidal elevations upon which the flood basin was designed, particularly the low tides.

- This tidal phenomenon influences PAFB operation to the point where the maximum level of stored water in the basin during the design one-percent runoff event is one foot higher than previously assumed. Due to inadequate freeboard along the basin's inboard levees, the Palo Alto Municipal Services Center (MSC) continues to be at a risk of flooding during periods of extreme runoff, as are low-lying residential and commercial areas southwest of Highway 101.

- Storage capacity within the PAFB has not significantly diminished since it was first created thirty years ago.

Channel Constriction Downstream of Highway 101. Matadero Creek does not empty immediately into the PAFB downstream of the Bayshore Freeway. Here the creek is contained between a levee to the north and the MSC to the south for a distance of about 1,200 feet. Based on aerial photographs, conditions in this reach of Matadero Creek have changed substantially over the past thirty years. Sediment accumulation and subsequent growth of dense vegetation within the creek overbanks has cut the available channel capacity in this reach by 50 percent. Even without the effect of tidal behavior on downstream starting water surface elevations, the channel constriction increases the one-percent flood stage at Highway 101 by 1.6 feet relative to conditions 30 years ago. Backwater effects can impact one-percent water surface elevations upstream to Bryant Avenue.

Channel Constrictions Upstream of Highway 101. Several bridge openings at Matadero Creek roadway crossings are of inadequate size to discharge the design one-percent flowrate with available head. The most critical of these is at Louis Road, whose bridge structure is also inadequate to resist the loading imposed on it when the bridge becomes pressurized. The combination of bridge area deficiencies means that with flow overbanking and ponding upstream of Alma Street eliminated, the one-percent discharge cannot be contained in Matadero Creek downstream of Alma, and overflows are predicted at Louis Road and Waverley Street.

Shallow flooding areas have also been identified at Hillview Avenue and Foothill Expressway due to limited culvert capacities. These flooding areas do not exceed about one-foot in depth and are confined so that the spills re-enter the creeks without causing serious property damage. These areas are not a part of this project.

FLOOD PROTECTION PROJECT ELEMENTS

Santa Clara County is divided into five zones. Each zone is defined by watershed boundaries and is essentially a unique fiscal entity. All revenue generated within a zone must be spent on the construction, operation, and maintenance of facilities that benefit that zone. Matadero and Barron Creeks are located in the Northwest Zone.

After flood problems within each zone are investigated in a long-range planning context, flood damage reduction needs are identified and prioritized on a project-by-project basis. The District has developed an integrated, multi-objective planning process that addresses flood damage reduction, erosion, sedimentation, maintenance, pollutants, recreation, and other watershed concerns. Alternative solutions are evaluated within the context of economic feasibility, environmental impact and mitigation, and community acceptability.

Evaluation of Alternative Solutions

Many conceptual project alternatives to meet project objectives have been considered for feasibility using flood protection, environmental impact and project cost as primary screening criteria. Conceptual alternatives include non-structural measures such as flood-proofing, upstream reservoirs, off-stream storage, flow diversions, and channel modifications. A total of ten conceptual solutions have been formulated and screened down to four feasible solutions which are evaluated using more refined criteria for environmental impact, project cost, maintenance, and other considerations such as construction schedule and local drainage.

Public Outreach

Community feedback and support for project alternatives have been actively sought during the preparation of this planning study. The District's staff and its consultants have met with and held public forums for residents, business owners, City of Palo Alto staff, Stanford University representatives, regulatory agencies staff, and members of the environmental community. This report is available for review by the public prior to final approval and publication by the District.

NFIP Regulations

It is the policy of the District to design flood damage reduction projects to contain the one-percent flood with appropriate freeboard. The one-percent flood is the standard level of protection established by the Federal Emergency Management Agency (FEMA), which is charged with administering the National Flood Insurance Program (NFIP). The NFIP requires flood insurance when financing, through federally backed institutions, structures located within a designated flood hazard area. Thus it is a goal of the District not only to reduce flood damage potential, but also to reduce the burden of mandatory flood insurance.

PROPOSED PROJECT

After carefully considering a number of alternative solutions in the context of flood damage reduction, economic feasibility, environmental impact, and long-term maintenance, the proposed project is recommended because it provides one-percent flood protection for the least overall capital cost and environmental impact. The project is a combination of bypass construction, channel modifications, and floodwall modifications. Its completion would allow the District to cease its emergency operation of the Barron Creek diversion facility, and provide one-percent riverine flood protection along both Matadero Creek and Barron Creek from Foothill Expressway to San Francisco Bay. Tidal flooding, which affects areas from the Bay to approximately Middlefield Road, is not addressed by the proposed project.

Proposed Flood Protection Measures

A plan for flood protection and future maintenance is presented in this report. An overflow bypass will be constructed from Highway 101 downstream to the Palo Alto Flood Basin, adjacent to the City of Palo Alto's Municipal Services Center. Flood walls will be raised from Highway 101 upstream to Alma Street. Channel modifications will be made at Louis Road, and the Louis Road Bridge will be replaced and elevated. The culvert-to-channel transition downstream of Alma Street will be improved. Project cost is approximately $14 million, of which $13.2 million is construction related, and $600,000 is for mitigation and $200,000 is for right-of-way (see Table 1-1).

Table 1-1
Matadero Creek Capital Improvement Project Cost Summary by Study Reach

Reach	*Limits*	*Reach Length (feet)*	*Project Element*	*Estimated Cost*
1	PAFB to U.S. 101	1,400	Overflow Bypass	$8,000,000
2A	U.S. 101 to Louis Road	2,330	Raise Floodwalls	$1,800,000
2B	Louis Road Bridge	120	Replace Bridge	$1,500,000
2C	Louis Road to Alma Street	5,500	Raise Floodwalls	$2,700,000
	TOTAL PROJECT COSTS			**$14,000,000**

Significant Environmental Impacts and Mitigation

Predicted environmental impacts and mitigation requirements are described in the project EIR. Environmental impacts and mitigation acreage for major project elements are listed in Table 1-2.

Table 1-2
Impacts and Mitigation for Proposed Project

		Mitigation		
Habitat	*Impact (ac)*	*On-Site (ac)*	*Off-Site (ac)*	*Total (ac)*
Willow Riparian	0.78	0.97	1.37	2.34
Freshwater Marsh	0.11	0.22	0.00-	0.22
TOTAL	0.89	1.19	1.37	2.56

Project Financing

A total budget of $24 million has been allocated for the Matadero / Barron Creeks Remediation Project. This budget includes all costs for engineering, construction, inspection, mitigation and administration. Funding for project completion will be provided by the District's capital funds allocated to the Matadero and Barron Creeks Remediation Project in the Lower Peninsula Watershed.

Construction Staging

Project construction could commence in Spring 2003 and be completed in early 2005. It is possible that work downstream of Highway 101 will be bid separately from channel, bridge, and floodwall modifications located upstream of Highway 101. The work downstream of Highway 101 is significantly different in terms of construction, environmental impact, and schedule. A schedule of construction staging is presented in Chapter 9, "Project Cost, Financing, and Staging."

CHAPTER 2
PROJECT BACKGROUND

This chapter introduces the Matadero and Barron Creek study area, discusses the history of flood protection efforts within south Palo Alto, summarizes project completion to date (as a result of the 1988 Engineer's Report), and presents identified facility inadequacies. Flood protection as provided by previously completed infrastructure and tested by the February 1998 event is discussed, as is the necessity for the remedial work outlined by this Engineer's Report and Environmental Impact Report. Finally, project objectives are outlined.

WATERSHED DESCRIPTION

Matadero and Barron Creeks drain about 60 percent of the 31.5 square miles tributary to the Palo Alto Flood Basin (PAFB) in Palo Alto (Figure 2-1). This planning study includes a comprehensive evaluation of the entire hydrologic and hydraulic regime within the PAFB watershed, with the exception of detailed hydraulic analysis for Adobe Creek. Major drainage basins tributary to the PAFB are listed in Table 2-1. The watershed is bounded by San Francisco Bay to the north, San Francisquito Creek to the west, the cities of Mountain View and Los Altos to the east, and the Santa Cruz Mountains to the south. Mountain View's Coast Casey Pump Station discharges to the PAFB, as do areas nominally tributary to San Francisquito Creek through Palo Alto's storm drain system, which will naturally drain back toward Matadero Creek once storm drain capacity is exceeded.

As shown on Figure 2-1, a facility that diverts flow from the Barron Creek watershed to the Matadero Creek watershed is available to partially regulate flood discharges downstream of Foothill Expressway.

Table 2-1
Palo Alto Flood Basin Watershed

Drainage	*Area (sq. mi.)*
Adobe Creek	10.8
Barron Creek	3.2
Matadero Creek	15.9
Coast Casey Pump Station	1.6
Total Tributary Watershed	**31.5**

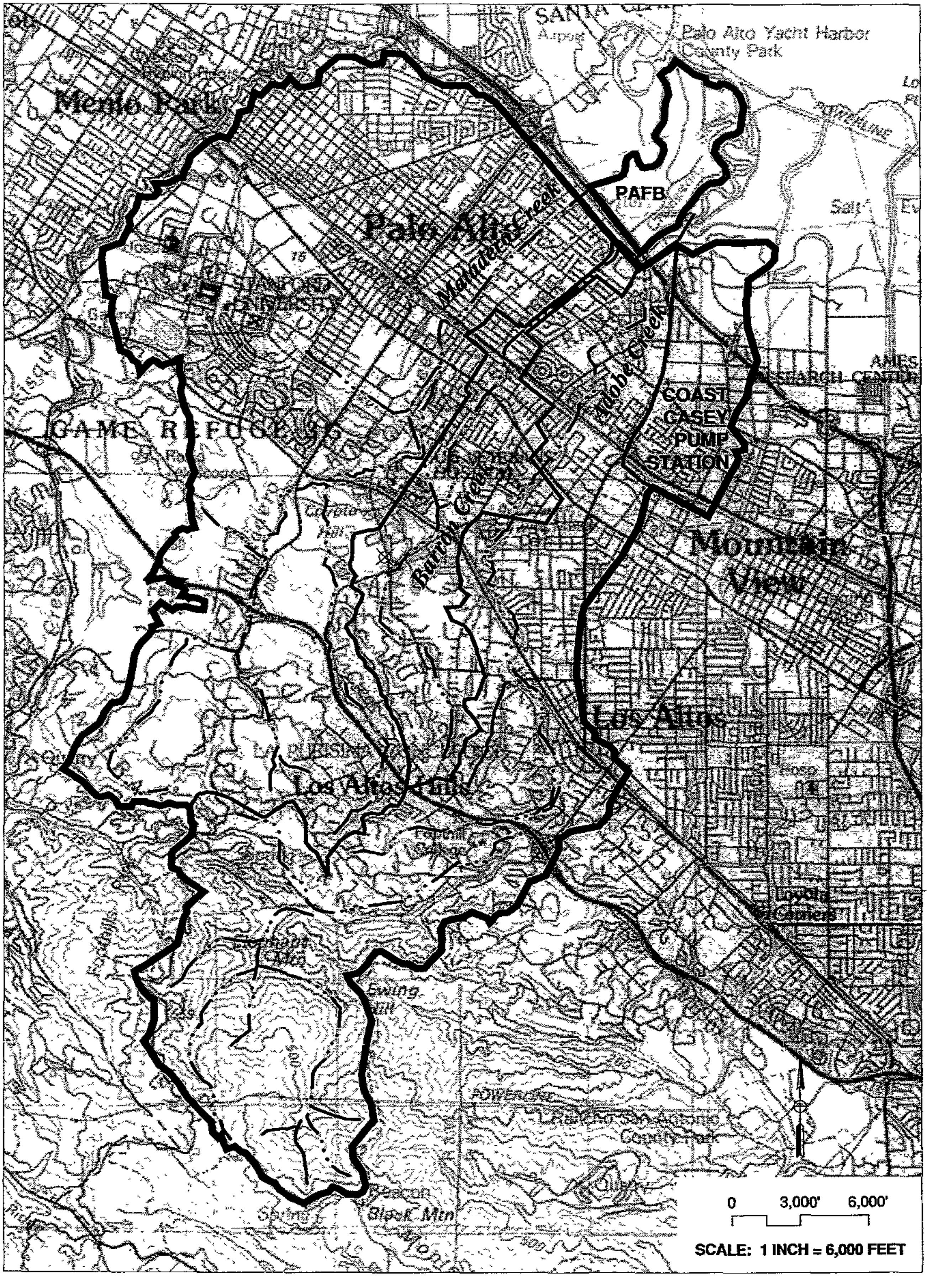

Figure 2-1. Palo Alto Flood Basin Watershed

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GEOLOGICAL AND HYDROLOGIC SETTING

The study area sits atop broad alluvial fans that were formed as streams emerged from the mountains onto the Santa Clara Valley floor and deposited unconsolidated materials as their slopes flattened. Closer to San Francisco Bay, shallow marine deposits consisting of fine grained deposits, silt, clay and "bay muds" characterize the geology. Flooding could be characterized as shallow sheet flow through much of the study area, with the lower portions near the baylands subject to tidal action.

Figure 2-2 shows a portion of an 1899 USGS Palo Alto Quadrangle. At the turn of the last century, Adobe Creek drained the eastern slope of the Santa Cruz Mountains directly to San Francisco Bay through Charleston Slough. What is now Barron Creek was an unnamed tributary to Matadero Creek with a confluence near the present-day diversion facilities. Matadero and Barron Creeks drained mountain and hillside areas to the location of present-day Laguna Avenue where, due to the flattened slope, the creek entered an alluvial fan of previous stream deposits. As the channel wound its way down the gently sloping fan, it appears to have been confined to an incised channel until it crossed the Southern Pacific Railroad (which is now the Union Pacific Railroad, but still in the same location), terminating near the town of Mayfield. Flood flows would overflow the channel and eventually find their way to San Francisco Bay through the Mayfield Slough.

ENVIRONMENTAL SETTING

Matadero and Barron Creeks flow through a mixture of land uses, from open space areas in the foothills, through the low-density hillside residential areas of Los Altos Hills, and through higher density suburban areas of Palo Alto.

Matadero Creek

Matadero Creek runs primarily in a natural channel from its tributary sources in the hills above Interstate 280, downstream to El Camino Real. The creek drains the foothills through a relatively narrow canyon that stretches from the confluence with Arastradero Creek alongside Old Page Mill Road, downstream to the intersection of Old Page Mill Road with Page Mill Road near Foothill Expressway. Valuable riparian habitat is located along these creek reaches, although horse pastures located between Deer Creek Road and Foothill Expressway have degraded the quality of adjacent stream habitats. Scattered rural residents are also located close to the creek throughout the canyon and upstream watershed.

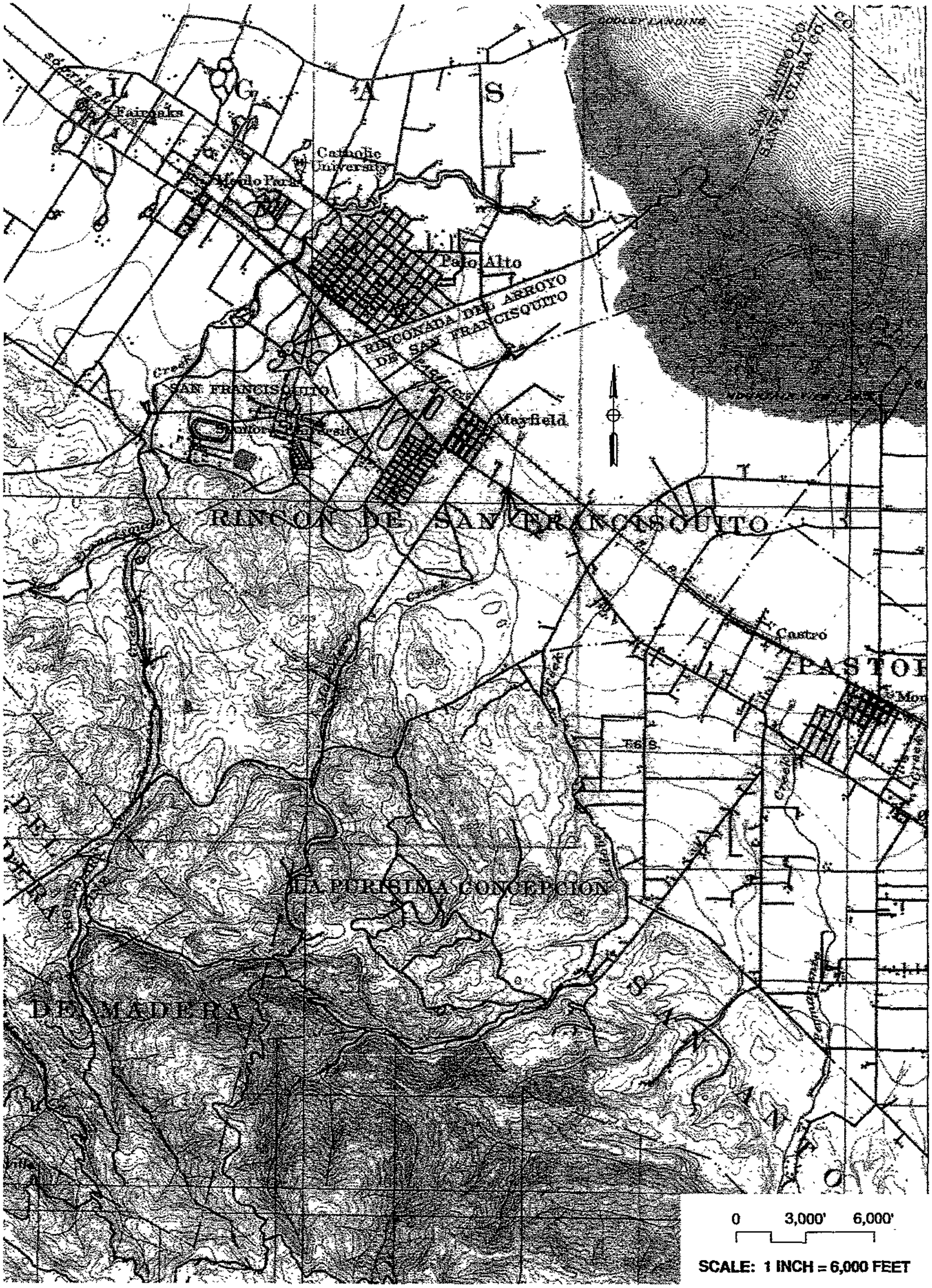

Figure 2-2. Portion of 1899 USGS Palo Alto Quadrangle

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Construction of the Matadero Bypass Channel has reduced flood damage potential while maintaining the natural riparian corridor from Foothill Expressway to El Camino Real. The only disruption to the natural creek through this reach is an 800-foot long underground culvert beneath the Stanford Management Group Tibco Campus (formerly the Watkins-Johnson site) near Hillview Avenue. In 1988, the bypass channel alternative was selected for this reach since it was the least costly plan and received strong support from the community (SCVWD, 1988). None of the work proposed within the present planning study would affect this natural creek reach.

Downstream of El Camino Real, Matadero Creek is contained within a concrete-lined channel of rectangular "U-frame" section to the Union Pacific Railroad (which was formerly the Southern Pacific Railroad; the two names are used interchangeably throughout this report). The vertical concrete walls of the "U" section have been extended above the natural channel bank as necessary to contain water and/or provide freeboard.

Below Alma Street, which is immediately downstream of the railroad, Matadero Creek is conveyed in a concrete-lined trapezoidal channel. Concrete floodwalls have been built to contain floodwater and/or provide freeboard. Closer to the Bay, the concrete-lining ends at Greer Road and the creek channel transitions to a sacked concrete-lined slope with an earthen bottom. Emergent wetland vegetation has established itself within this reach, which is prone to the accumulation of sediments, particularly bed load.

Downstream of Highway 101, the Matadero Creek flows through a riparian corridor before it enters the Palo Alto Flood Basin. This riparian corridor contains both native and non-native plant species. Attempts have been made to control the invasion of non-native species occupying space that could otherwise support native species with higher habitat values, as discussed in the project EIR.

Environmental settings for Matadero Creek reaches are summarized by Table 2-2. Photographs keyed to the table are presented on the following pages.

Table 2-2
Matadero Creek Reaches

Reach	Photo #	Description
Above Foothill Expressway	1	natural riparian channel
Foothill Expwy to Bypass Channel	2	natural riparian channel
Bypass Channel	3, 4	12' x 12' box culvert
Creek, Bypass to El Camino Real	5	natural riparian channel
El Camino Real to Railroad	6	concrete-lined "U frame"
Alma Street to Greer Road	7, 8, 9	concrete-lined trapezoidal
Greer Road to Highway 101	10, 11	SCSP banks, earth bottom
Highway 101 to PAFB	12	excavated riparian channel

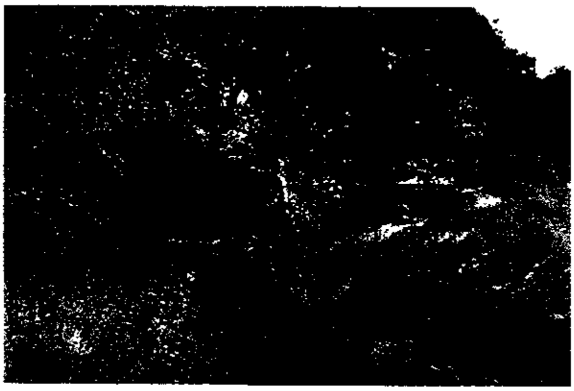

Photo 2-1 Matadero Creek Looking Upstream from Foothill Expressway

Photo 2-2 Matadero Creek Looking Upstream from Hillview Avenue Culvert

Photo 2-3 Matadero Creek Looking Upstream from Bypass Structure

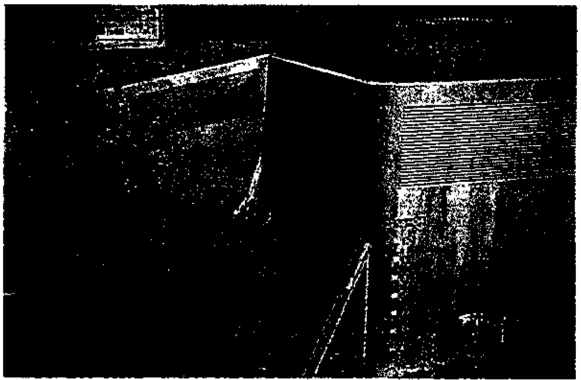

Photo 2-4 Matadero Creek Bypass at Upstream Face of Bol Park Bike Trail

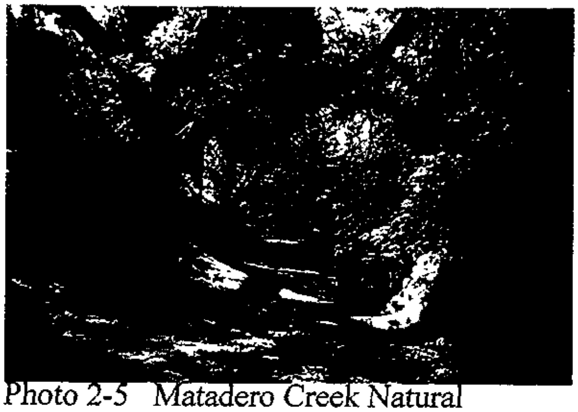

Photo 2-5 Matadero Creek Natural Channel Looking Upstream at Bol Park

Photo 2-6 Matadero Creek Looking Upstream from Lambert Avenue Bridge

Photo 2-7 Matadero Creek Downstream Face of Alma Street Bridge

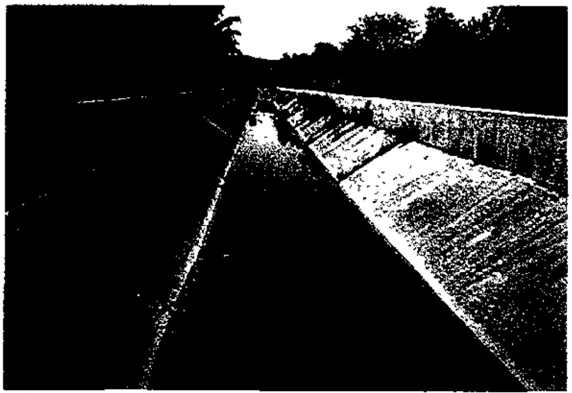

Photo 2-8 Matadero Creek Looking Upstream from Louis Road Bridge

Photo 2-9 Matadero Creek Downstream Face of Louis Road Bridge

Photo 2-10 Matadero Creek Looking Downstream from Greer Road Bridge

Photo 2-11 Matadero Creek Looking Downstream from Underneath Highway 101 Bridge

Photo 2-12 Matadero Creek Downstream of Highway 101

Barron Creek

Barron Creek begins in the hills above Interstate 280 in the Town of Los Altos Hills, and flows as a natural stream to Gunn High School, just downstream of Foothill Expressway. The Barron Sediment Basin and Barron Diversion Structure have been built to divert high flood flows from the Barron Creek watershed into the Matadero Creek watershed (Figure 2-3). Low flows leaving the diversion structure are conveyed to Barron Creek in a storm drain pipe underneath the Gunn High School playing fields.

From Gunn High School to Laguna Avenue, Barron Creek flows in a natural stream channel adjacent to residential properties. Between Laguna Avenue and El Camino Real (a distance of 3,000 feet), creek discharge is conveyed in a buried 60-inch diameter pipe. Between El Camino Real and about 1,000 feet above the confluence with Adobe Creek, Barron Creek is concrete-lined and trapezoidal in section. Concrete floodwalls have been built downstream of Louis Road.

In the lower reaches of Barron Creek, the channel is leveed with sack concrete slope protection (SCSP) and an earth bottom, which has remained clear of vegetation. Downstream of the Barron/Adobe Creek confluence, the combined channel is concrete lined. After crossing Highway 101, Adobe Creek flows through a riparian corridor until it reaches the Palo Alto Flood Basin.

Photographs of various reaches of the creek are keyed on Table 2-3, and follow in the report.

Table 2-3
Barron Creek Reaches

Reach	*Photo #*	*Description*
Foothill Expwy to Sediment Basin	13	natural riparian channel
Barron Creek Diversion	14	10' x 6' box culvert
Gunn High School		60-inch diameter pipe
Gunn to Laguna Avenue	15	natural creek
Laguna Ave to El Camino Real		60-inch diameter pipe
El Camino Real to Sta 10+40	16 - 20	concrete-lined channel
Sta 10+40 to Adobe Creek	21	SCSP, earth bottom, leveed
Adobe Creek to Highway 101	22	concrete-lined, earth bottom
Highway 101 to PAFB	23	riparian channel

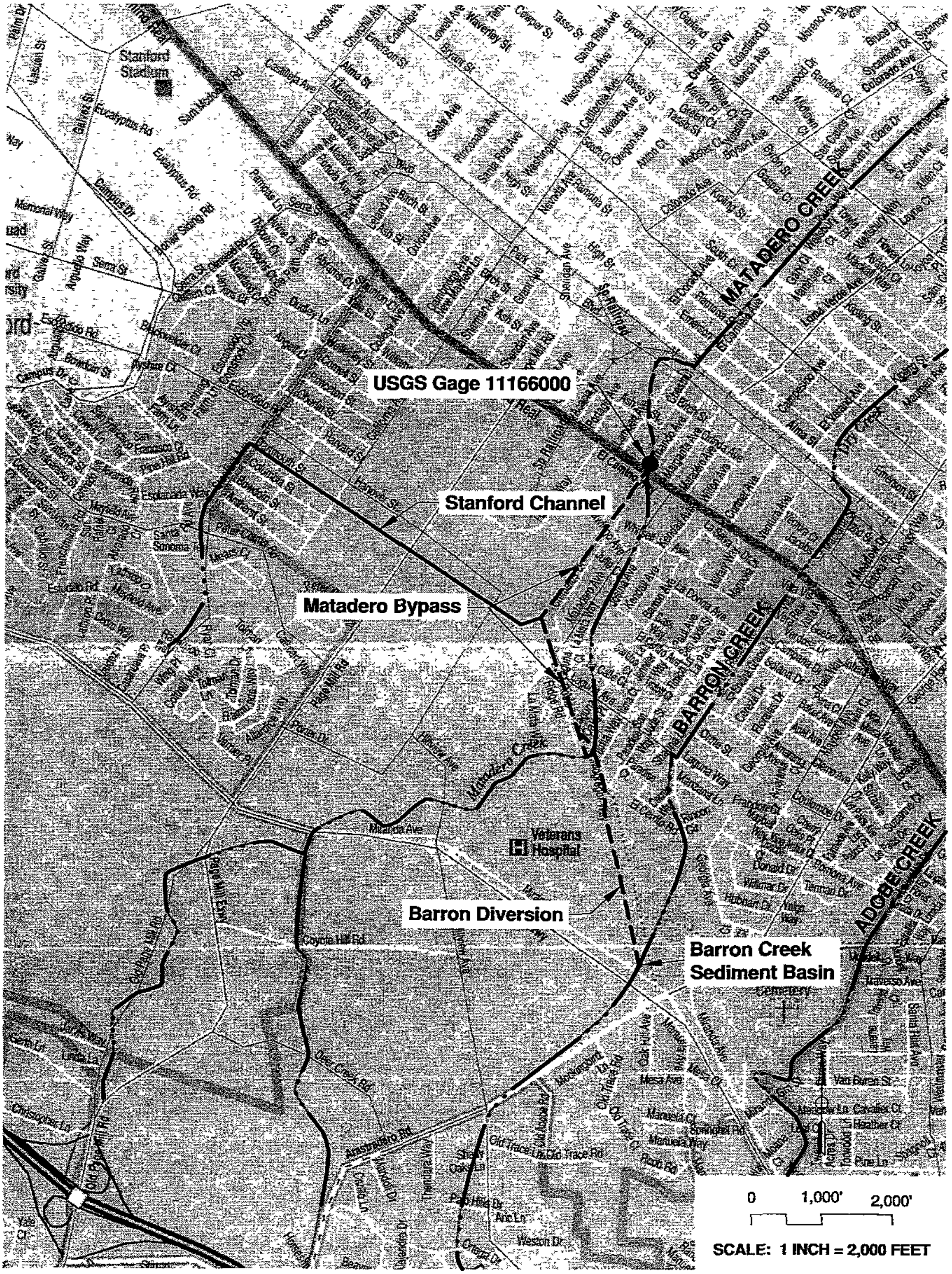

Figure 2-3. Facilities Completed in 1997

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Schaaf & Wheeler

Photo 2-13 Barron Creek Downstream Face of Gunn High School Footbridge

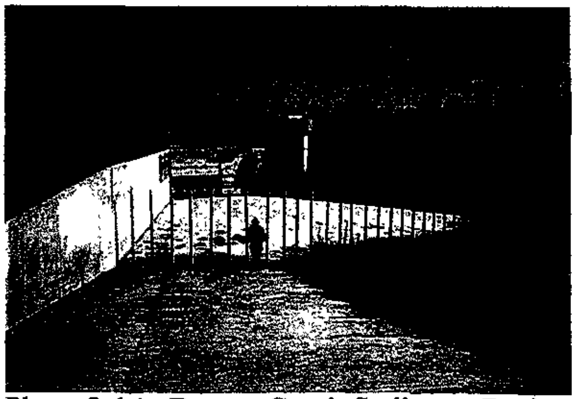

Photo 2-14 Barron Creek Sediment Basin and Diversion Gates

Photo 2-15 Barron Creek Looking Downstream at Los Robles

Photo 2-16 Barron Creek Looking Upstream at Park Boulevard

Photo 2-17 Barron Creek Looking Downstream from Ramona Street Bridge

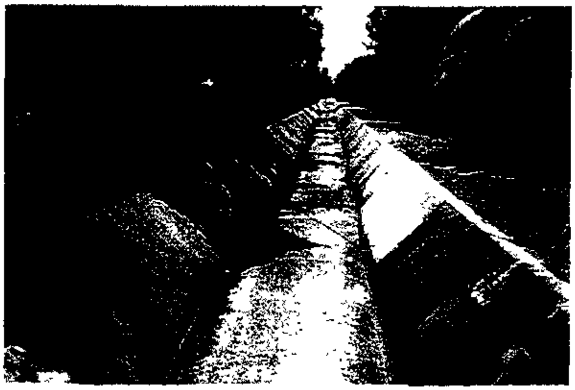

Photo 2-18 Barron Creek Looking Downstream from Ross Road Bridge

Photo 2-19 Barron Creek Downstream Face of Louis Road Bridge

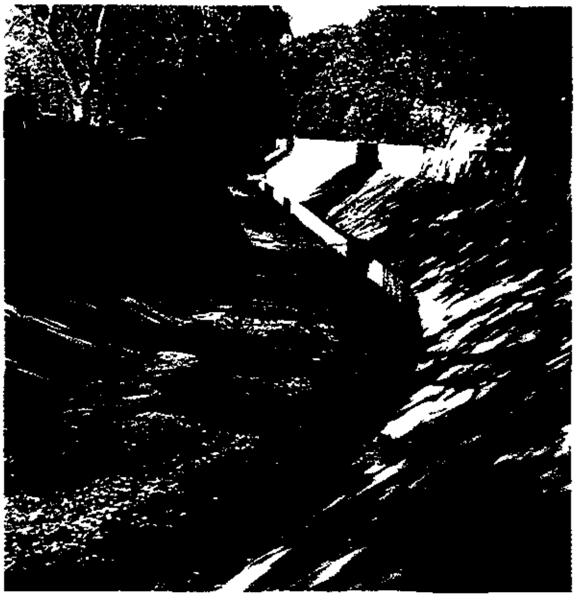

Photo 2-20 Barron Creek Looking Upstream of E. Meadow Drive

Photo 2-21 Barron Creek Looking Upstream of Fabian Road

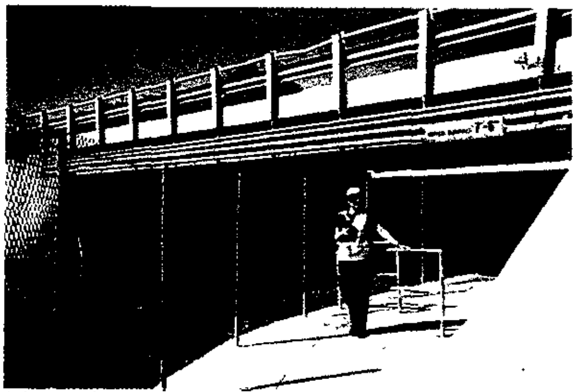

Photo 2-22 Barron Creek Upstream Face of Fabian Road Bridge

Photo 2-23 Barron/Adobe Creek Downstream of Highway 101

Palo Alto Flood Basin

The Palo Alto Flood Basin (PAFB) was created in 1956 with the construction of levees surrounding a 600-acre portion of the Palo Alto Baylands. The flood basin is owned by the City of Palo Alto. The District has maintenance easements for the levees and 15 of the 16 tide gates that make up the flood control component of this facility. The City of Palo Alto is responsible for one tide gate, which is also equipped as a motorized sluice gate that can be opened to allow two-way circulation between San Francisco Bay and the wetland marsh of the basin. In 1973, the City of Palo Alto designated the flood basin as a wetlands preserve.

Figure 2-4 shows an April 1999 aerial photograph of the PAFB. The basin extends east-northeast from Highway 101 and receives inflow from Matadero Creek, Adobe Creek, Barron Creek, and the Coast Casey Stormwater Pumping Station. Inflow is stored in the PAFB and released to San Francisco Bay through a tide gate structure. This structure consists of 16 box culverts (each 5 ft. by 5 ft. in dimension) with flap gates at each downstream face. These flap gates open when the stage in the PAFB is higher than the San Francisco Bay tide heights. The gates close when the tide rises to prevent Bay waters from entering the PAFB, thereby maintaining available volume for holding creek runoff during high-flow events. During summer months, the City of Palo Alto opens one of the tide gates to allow circulation of seawater in the PAFB. All of the tide gates have an invert elevation of -5.1 ft. NGVD'29.

Inboard flood basin levee elevations have been a point of contention for many years. (Inboard levees are the levees along Bayshore Freeway that contain stored freshwater, as opposed to the outboard levees which protect Palo Alto from San Francisco Bay.) When the District's 1974 report was published, the desired minimum levee elevation was set at 7.0 feet (NGVD'29) using imported materials, in order to provide 2.3 feet of freeboard above the one-percent design operating water level within the basin (estimated as 5.7 feet). Based partly on the flood basin's designation as a wetland preserve, the City of Palo Alto opposed raising levees to an elevation of 7.0 feet. The City then independently sought advice from a private consulting firm, to resolve whether the levee raising project was necessary. That firm stated that the maximum one-percent operating level in the flood basin was 3.1 feet (NGVD'29), and with minimum inboard levee elevations of 3.5 feet (NGVD'29) at the time, no further work was necessary. (A current analysis of PAFB operation is provided in Appendix G.)

Eventually, the District and City reached a negotiated compromise, whereby the minimum levee elevation was set at 6.1 feet (NGVD'29). This elevation appears to be generally consistent with current surveyed field conditions.

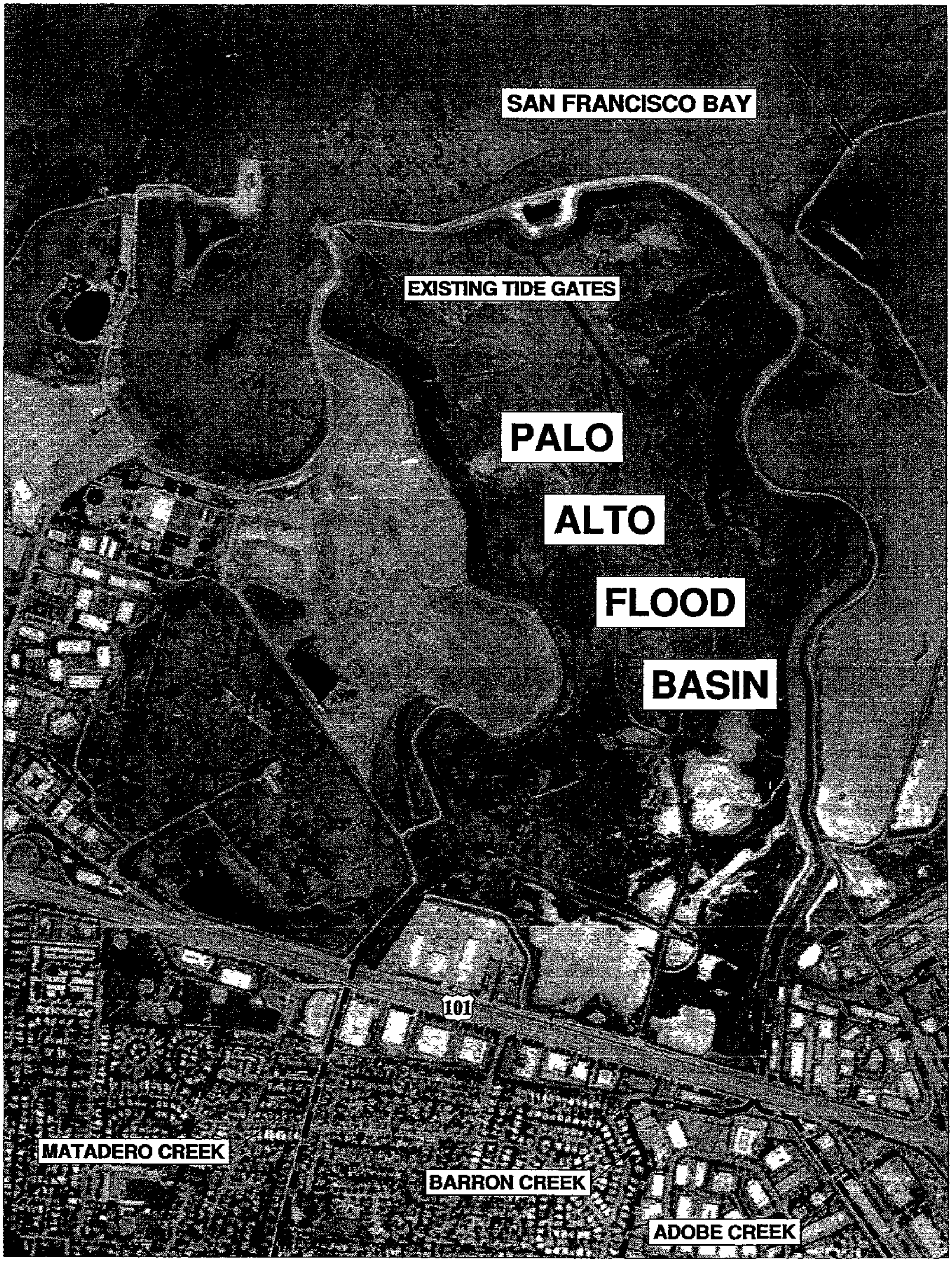

Figure 2-4. Palo Alto Flood Basin

Aerial Photo by Towill Engineers, April 1999

HISTORY OF FLOODING WITHIN THE WATERSHED

Significant flooding events in February 1940, December 1955, and April 1958 demonstrated the need for flood control protection to this growing area of Palo Alto. In 1940 flood waters overtopped the banks of Matadero and San Francisquito Creeks and damaged agricultural property on both sides of the Bayshore Freeway (U.S. Highway 101). Area property values increased as agricultural land converted to residential, commercial and industrial uses. In late December 1955, heavy rainfall, combined with debris accumulation at the freeway bridge, resulted in overtopping near Highway 101, closing the roadway and inundating many homes and businesses. The 1958 flood event resulted from a break in the south levee of San Francisquito Creek. Water flowed south and combined with Matadero Creek overflows to the City of Palo Alto Municipal Services Center (MSC).

Flood Protection Projects

Flood damages experienced during the 1950s led to a series of flood protection projects beginning with the creation of the Palo Alto Flood Basin (PAFB) in 1956. This tidal basin was created by constructing perimeter levees around a 600-acre tidal marsh area adjacent to San Francisco Bay to protect low-lying areas of Palo Alto. A series of 16 one-way tide gates allow for the storage of fluvial runoff during periods of high tides; the stored water is released during periods of lower tide.

To provide additional flood flow conveyance, the Matadero Creek channel was concrete-lined from Alma Street to Greer Road following the 1955 flood. Thus, downstream of Alma Street (and the Southern Pacific Railroad) Matadero Creek is an entirely man-made channel which historically did not exist as a natural watercourse.

Land subsidence resulting from groundwater overdrafting from 1920 to 1970 led to a reduction in flood flow conveyance for Matadero Creek. (Ground along the creek between Bayshore Freeway and Middlefield Road subsided over three feet during that period of time.) Levees and floodwalls were built in 1971 along stream banks in the area to compensate for the subsidence and contain flood waters in the channels.

Flood Insurance Study Published in 1980

The first Flood Insurance Rate Map (FIRM) for the City of Palo Alto was published February 15, 1980 for the NFIP and presented the flooding situation after the completion of levee work in the early 1970s. The currently effective FIRM of June 2, 1999 has not substantially changed since 1980 within the planning area (Figure 2-5).

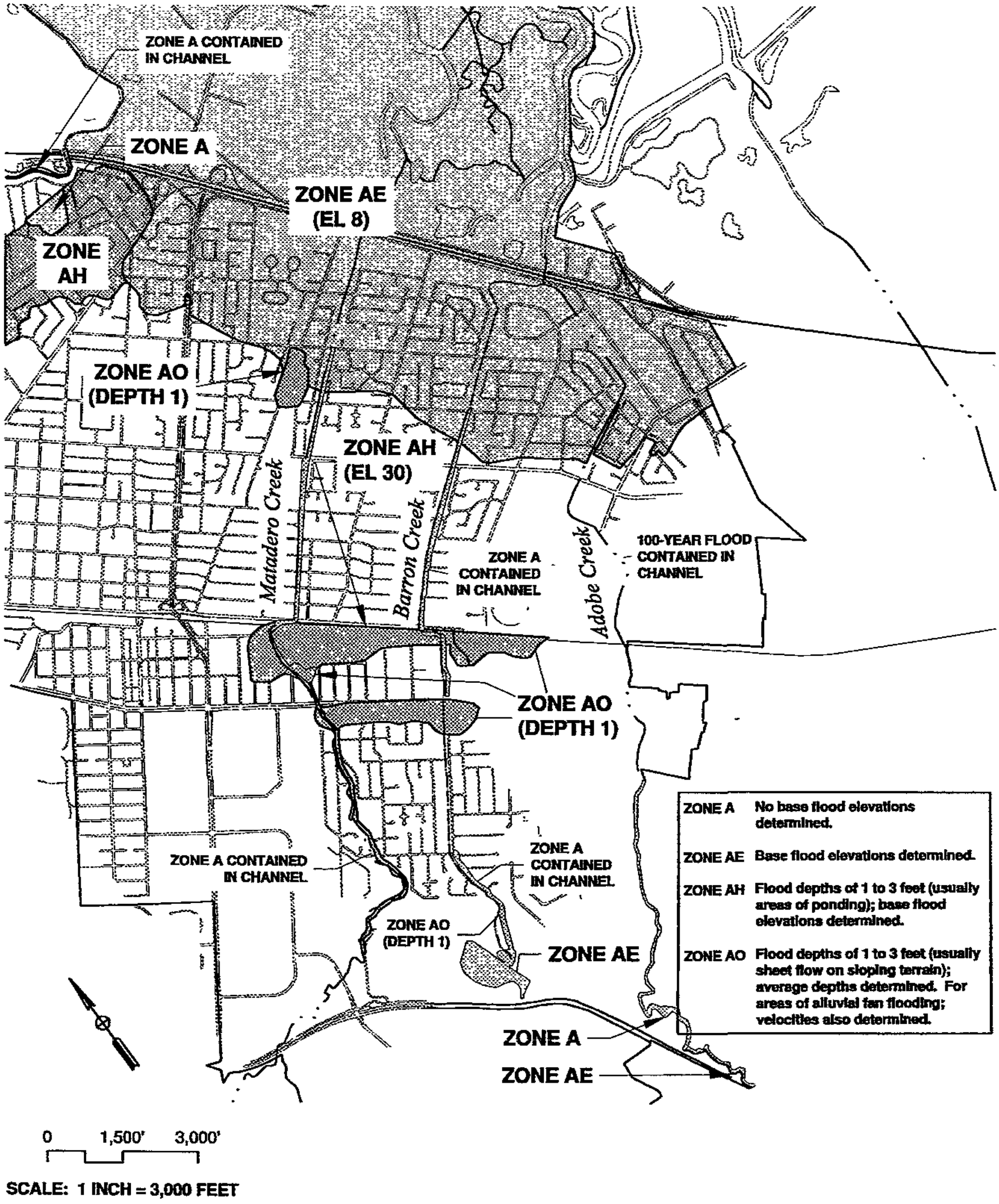
ZONE A CONTAINED IN CHANNEL
ZONE A
ZONE AE (EL 8)
ZONE AH
ZONE AO (DEPTH 1)
ZONE AH (EL 30)
Matadero Creek
Barron Creek
Adobe Creek
ZONE A CONTAINED IN CHANNEL
100-YEAR FLOOD CONTAINED IN CHANNEL
ZONE AO (DEPTH 1)
ZONE A CONTAINED IN CHANNEL
ZONE A CONTAINED IN CHANNEL
ZONE AO (DEPTH 1)
ZONE AE
ZONE A
ZONE AE
ZONE A No base flood elevations determined.
ZONE AE Base flood elevations determined.
ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding; velocities also determined.
0
1,500'
3,000'
SCALE: 1 INCH = 3,000 FEET

Figure 2-5. 1999 FIRM for Matadero and Barron Creeks

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Properties between San Francisco Bay, Embarcadero Road, East Charleston Road and a diagonal struck from the intersection of Greer Road with North California Avenue to the intersection of East Charleston Road with Middlefield Ross were placed within the 100-year tidal floodplain in 1980. At that time, the occurrence of flood flows leaving the creek channels at the railroad and El Camino Real prevented overtopping of Matadero Creek or Barron Creek downstream. The spills upstream of the railroad caused ponding as far upstream as Ash Street between Acacia Avenue to the west and Tennessee Lane to the east, and shallow flooding toward the Bay. An area south of El Camino Real between Matadero Creek and Vista Avenue had greater flood depths and was established as an AO zone on the FIRM. Lenders still require property owners in the two areas to purchase and carry flood insurance.

PREVIOUS ENGINEERING STUDIES AND CONSTRUCTION

A planning study prepared by the District in 1988 proposed to eliminate flood insurance requirements for all properties affected only by flooding on Matadero or Barron Creek, and to reduce the flood threat within the established tidal zone and San Francisquito Creek's floodplain. The recommended project features, which were completed by July 1996, included:

1) Additional floodwalls along the existing concrete-lined Matadero Creek channel, and along Barron Creek upstream from the sedimentation basin;

2) Bridge replacements at Greer Road, Louis Road, Ross Road, Middlefield Road, Cowper Street, and Waverley Street, the Southern Pacific Railroad, Park Boulevard, Lambert Avenue, and El Camin~~o~~ Real;

3) Realigned and enlarged channel between Alma Street and Park Boulevard;

4) Replacement of trapezoidal channel with 25-foot wide rectangular "U-frame" channel between Park Boulevard and El Camino Real;

5) High flow underground box culvert from the old railroad bridge at the upstream end of Bol Park to El Camino Real; and

6) A high flow underground diversion from the Barron Creek sedimentation basin near Gunn High School to Matadero Creek at the new bypass location. This facility can divert sufficient flow so that the flow remaining in Barron Creek can be adequately conveyed from Gunn High School to the confluence with Adobe Creek.

1988 - 1997 Project Inadequacies Identified

While preparing a Letter of Map Revision (LOMR) application to FEMA subsequent to the completion of the facilities recommended by the 1988 Engineer's Report (Chapter 2), District staff discovered errors in their hydraulic analyses, and as a result, the completed project provided a substantial increase in the level of flood protection along Matadero and Barron Creeks, but did not meet FEMA freeboard standards. Several reasons for this are suggested by District staff and this planning effort:

Design Freeboard Less than Current FEMA Standards. In the 1988 Engineer's Report, the District proposed a design freeboard of two (2) feet for channels with concrete floodwalls. FEMA's definition of a levee does not distinguish between concrete floodwalls and earthen embankments, and three (3) feet of freeboard (with an additional foot within 100 feet of bridges or other constrictions) are required for any man-made structure designed for flood protection [NFIP §65.10(b)(1)]. However, the FEMA standards in place when the 1988 Engineer's Report was written and current FEMA standards both allow for a relaxation of freeboard requirements if the "levee owner can demonstrate that protection from the one-percent change flood can be reasonably assured with a lesser freeboard." [Federal Register, Vol. 51, No. 164, August 25, 1986]

Design Starting Water Surface Elevation Underestimated. Hydraulic models used in the 1988 planning study begin with a starting water surface in the PAFB at 3.5 feet (NGVD'29) when Matadero Creek is at its peak discharge, and 5.7 feet (NGVD'29) when the flood basin is at its highest stage. Analyses in the present planning study find that starting water surface elevations should be 4.6 feet and 6.5 feet, respectively (Appendix G).

Reduced Channel Conveyance Downstream of Highway 1~~01~~. Sediment deposits and the resulting riparian vegetation growth within Matadero Creek between the PAFB and Highway 101 have reduced channel conveyance by nearly 50 percent. Existing channel conditions essentially control the design water surface elevation at Highway 101; and relative to channel conditions assumed in 1988, impact the design water surface profile upstream to Bryant Street. Hydraulic modeling upon which the 1988 Engineer's Report was founded does not reflect the current heavily silted and vegetated channel condition in this reach (Chapter 3).

Invalid Hydraulic Assumptions at Certain Bridges. The hydraulic analysis in 1988 did not account for energy losses through bridge constrictions under pressure flow conditions. Although the 1988 design one-percent water surface profile showed pressurized bridges at Greer and Louis Roads, they were modeled using a method that only accounts for friction loss through the bridge itself, which underestimates actual energy losses through the bridges during high flow (pressurized) conditions when each bridge acts as a flow orifice. As a result of the increased headwater on each bridge, upstream bridges also pressurize under high discharge conditions, further exacerbating the problem. This concept is illustrated more fully in Appendix H.

Invalid Supercritical Flow Assumption Upstream of Ross Road. Above Ross Road, the 1988 planning study assumed supercritical flow with the design water surface carried below each bridge soffit. However, because of the aforementioned reasons, the actual design water surface elevation at the downstream face of Ross Road is higher than anticipated, causing this bridge to pressurize when conveying the design one-percent discharge. Backwater from the Ross Road Bridge invalidates the assumption of supercritical flow further upstream. Bridges at Cowper Street and Waverley Street are also pressurized under design conditions, which was not assumed in the 1988 planning study. This concept is also discussed in Appendix H.

Performance During the February 1998 El Niño Storm Event

Problems with the 1988 channel design had been identified by 1997. In November of that year, District officials developed a temporary emergency operations plan to balance flood protection between Matadero and Barron Creeks during high-flow events. One of two culvert barrels at the Barron Creek diversion was sealed with a moveable plate, with District staff prepared to monitor creek levels along both creeks and manually control the amount of flow diverted from Barron to Matadero Creek. The District's temporary remedy was tested during the February 1998 El Niño storm event, which produced the highest runoff recorded at the USGS Matadero Creek stream gage, and was close to the design one-percent event.

During this event, District records indicate that their staff opened the second barrel of the Barron Creek diversion at 9:30 p.m. on February 2, 1998. The peak flood wave (as recorded by the USGS stream gaging station) on Matadero Creek passed El Camino Real at roughly 12 o'clock midnight. Sometime shortly after 12:00 a.m., staff closed the second diversion barrel in response to rising creek levels at Waverley Street. In retrospect, Matadero Creek was able to handle nearly its peak discharge during the storm event of February 2-3, 1998 without spilling, although anecdotal information from that event suggest that the water surface was within one foot of the top of floodwalls near Greer Road and Louis Road. Had the second diversion barrel not been closed when it was, approximately 300 cfs would have been added to the peak flow in Matadero Creek. Sufficient freeboard to meet FEMA standards was clearly not provided downstream of Alma Street during the 1998 flood.

WATERSHED HYDROLOGY

The flood protection measures constructed within the Matadero and Barron Creek watersheds between 1988 and 1997 were based on a hydrologic analysis performed ten years earlier (SCVWD, 1977). To take advantage of additional Matadero Creek streamflow records between 1977 and 2000 (essentially doubling the length of record), watershed hydrology has been re-examined for this study. This re-examination serves to provide estimates of one percent design discharges in the Matadero and Barron Creek system for further hydraulic analyses.

Table 2-4 summarizes the findings of this hydrologic analysis. Proposed design discharges are listed along with the current effective flowrates that correspond to the 1999 Flood Insurance Rate Map shown in Figure 2-5. The inclusion of additional annual peak streamflow data has slightly changed estimated one-percent discharges throughout the watershed. The completion of flood protection measures in 1997 has reduced Barron Creek discharge downstream of the diversion structure, and commensurately increased discharge into the Matadero Creek system. Channel and bridge improvements have also increased Matadero Creek discharge downstream of the SPRR by eliminating channel overflows. Readers interested in more details regarding hydrologic analyses are referred to Appendix F of this report.

Table 2-4
Peak Flood Discharges

Location	*Published FEMA Discharge (cfs)*	*Proposed Design Discharge (cfs)*
Barron Creek		
Foothill Expwy	760	740
Laguna Ave.	180	160
SPRR	920	250
Adobe Creek	430	250
Matadero Creek		
Foothill Expwy	1,810	1,900
El Camino Real	2,280	2,700
SPRR	2,520	2,800
Middlefield	1,900	2,800
Louis Road	1,500	2,800
Highway 101	1,775	3,100

PROJECT OBJECTIVES

The basic project objective is to provide a level of flood protection along Matadero and Barron Creeks consistent with District policies and the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NFIP).

Base Flood Definition

NFIP regulations define the "base flood" as a flood having a one percent chance of being equaled or exceeded in any given year. Often this is referred to as a "one-percent" or "100-year" flood. This should not be confused with a flood that *will* occur once every one hundred years, but one that might occur once every one hundred years or so *on the average* over a very long period of time. In fact, over the life of a 30-year mortgage, there is a 26 percent chance of experiencing a flood equal or greater in magnitude than the base flood as demonstrated by Table 2-5.

Table 2-5
Relative Risk of Various Flood Events

	10-year	*100-year*
Exceedance Probability[1]	10%	1%
Risk of at least one event in 10 years	65%	10%
Risk of at least one event in 30 years	96%	26%
Risk of at least one event in 50 years	99%	39%
Risk of at least one event in 100 years	99.997%	63%

[1] Probability (risk) of at least one event greater than or equal to a certain magnitude in a given year.

Freeboard

The use of design "freeboard" provides a measure of safety that compensates for the many unknown and difficult-to-quantify parameters that affect the calculation of flood elevations. According to the NFIP, freeboard is required to "offset the hazards that might arise from underestimation of one-percent flood elevations as a result of uncertainties in the hydraulic and hydrologic analyses." Freeboard is usually expressed in terms of feet above the design one-percent flood elevation. To meet FEMA standards, freeboard is necessary whenever a levee system is used to provide flood protection.

NFIP regulations define a levee as a "man-made structure, *usually* an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding." [emphasis added] Structural floodwalls, although not earthen, are included in FEMA's definition of a levee system.

When mapping flood-prone areas, FEMA only recognizes those levee systems meeting the following minimum design criteria [NFIP §65.10(b)]:

> "For levees to be recognized by FEMA, evidence that adequate design and operation and maintenance systems are in place to provide reasonable assurance that protection from the base flood exists must be provided. The following requirements must be met:
>
> (1) Freeboard. (i) Riverine levees must provide a minimum of three feet above the water-surface level of the base flood. An additional one foot above the minimum is required within 100 feet in either side of structures (such as bridges) riverward of the levee or wherever the flow is constricted...
>
> (ii) Occasionally, exceptions to the minimum riverine freeboard requirements...may be approved. Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted to support a request for such an exception. The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include...an assessment of statistical confidence limits of the 100-year discharge; changes in stage-discharge relationships; and the sources, potential, and magnitude of debris, sediment, and ice accumulation. It must also be shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed. Under no circumstances will freeboard of less than two feet be accepted."

FEMA and District freeboard requirements (SCVWD, 1994) are summarized in Table 2-6.

Table 2-6
Freeboard Criteria

Situation	*FEMA (Feet)*	*District (Feet)*
Water Surface Above Natural Bank Elevation	3.0	3.5
Water Surface Above Bank at Upstream Limit of Levee	3.5	3.5
Water Surface Above Bank within 100 feet of Structure	4.0	4.0
Water Surface Below Natural Bank Elevation	N/A	$0.2(D + V^2/2g)$
Minimum Freeboard	N/A	1.0

District guidelines suggest that freeboard at new bridges be the same as in the existing or proposed channel either upstream or downstream, whichever is greater, so that a system with a uniform level of protection is provided. For existing bridges that may convey the one-percent flood under pressure, the guideline is that the bridge must be structurally sound and able to resist the resultant lateral and uplift forces.

Other Criteria

District standards also call for the consideration of other criteria when designing new flood conveyance facilities. Wherever practical, these additional criteria will be used to guide the rehabilitation of Barron and Matadero Creeks:

1) An evaluation of bridges under debris loading, by assuming a blockage equal to three times the bridge pier diameter.

2) Freeboard should contain the discharge defined by the 80 percent confidence limit when practical to do so.

3) Channels with supercritical flow shall be designed for sequent depth plus freeboard.

4) Channels shall include freeboard for super-elevation of the design water surface at curves in addition to the requirements listed above.

5) Additional freeboard allowances may be made in areas where continued land subsidence is anticipated.

Additional Project Objectives

As presented at the beginning of this chapter, the basic project objective is to provide a level of flood protection along Matadero and Barron Creeks that meets District and FEMA standards. Each creek must convey the one-percent discharge with adequate freeboard.

Additional project objectives include:

- Providing equivalent levels of flood protection throughout the project area and reduce the risk of riverine flooding in the areas currently mapped within the zone of one-percent tidal inundation;

- Protecting sensitive habitats within the Matadero/Barron Creek watersheds and determine if any environmental enhancement opportunities can be undertaken in conjunction with the project as discussed in the EIR;

- Providing for efficient and cost-effective flood control maintenance to ensure that the District is able to maintain design system performance in the future; and

- Obtaining a letter of map revision from FEMA to remove a substantial number of properties upstream of Alma Street / Central Expressway from the Special Flood Hazard Areas that are shown on the Flood Insurance Rate Maps.

Remedial work on the Matadero and Barron Creek system will not alter the mapped zone of tidal inundation between Middlefield Road and San Francisco Bay, nor the area of flooding caused by San Francisquito Creek spills. However, one project objective is to reduce the risk of flooding in these areas from two significant sources: Matadero Creek and Barron Creek. Furthermore, a most important objective is to provide for equivalent levels of flood risk throughout the project area.

Future Flood Protection Projects

Selected project alternatives must be functional under both existing conditions and likely flood protection plans that could impact Matadero or Barron Creeks. Such plans might include improvements to outboard Bay levees, Palo Alto Flood Basin levees, and corrective action on San Francisquito Creek.

Community Support

Finally, community support is another project objective. An extensive public outreach program throughout the planning phases of the work has provided excellent feedback. Many public comments have been incorporated into the planning study and the establishment of selection criteria for project alternatives. Public input has also been considered in the design of project features.

CHAPTER 3

PROBLEM IDENTIFICATION

This chapter describes problems identified in the Matadero Creek and Barron Creek watersheds that are solved by the proposed project. Current levels of flood protection, maintenance concerns, sedimentation, and local drainage problems are discussed.

CURRENT LEVEL OF FLOOD PROTECTION

Although the 1988 flood control project completed in 1997 did not meet the specific objective of providing flood protection meeting national and District freeboard standards, that project has measurably reduced the community's exposure to flood damage. In February 1998, the system was able to pass the flood of record without property damage. An emergency operating plan for the Barron Creek diversion facility allows for the maximization of flood protection in the study area.

Emergency Operating Plan

The District has adopted a plan of operation for the Barron Creek Diversion that provides increased protection on Barron Creek without increasing the level of flood risk on Matadero Creek. An adjustable steel plate has been placed over the entrance to one of the two the diversion barrels at the Barron Creek Sediment Basin. This allows District personnel to limit the rate at which flow is diverted from Barron Creek into the Matadero Creek Bypass (Figure 2-3).

During flood events, water surface levels in Matadero Creek are continuously monitored at Waverley Street. This information is transmitted to personnel standing by at the diversion gates. Once creek water levels reach a predetermined elevation at Waverley Street, the maximum amount of water that can be diverted into the Matadero Creek watershed is reduced from 600 cfs to 300 cfs, until the creek returns to a safe level. As long as Matadero Creek can safely accommodate diverted flows, flood protection along Barron Creek is improved relative to pre-1988 conditions.

Flood Risk on Matadero Creek

Under the emergency operating plan described above, design one-percent flow rates on Matadero Creek are reduced by up to 300 cfs. In this case, Matadero Creek may overtop Louis Road and Waverley Street during a base flood, and the flood flows would be conveyed with inadequate freeboard in other reaches of the creek.

The area of potential one-percent flood damage has been reduced since the completion of the 1988 project and implementation of the emergency operation plan as shown by Figure 3-1. Table 3-1 summarizes flood damages before the completion of the 1988 project, while Table 3-2 lists annual flood damages after completion of the project, assuming that no more than 300 cfs are diverted to Matadero Creek under emergency conditions. Both tables provide flood damage estimates for various land use categories. Flood sources include overflows from Matadero and Barron Creeks, and local drainage. Damages in the area due to tidal flooding or overflows from San Francisquito Creek are not shown on Figure 3-1 or included in either damage assessment. For reference, Figure 3-1 shows the limit of one-percent tide inundation in the event of bayfront levee failure. The 1988 project has reduced one-percent riverine flood damage from $370 million to $320 million.

Table 3-1
One-Percent Riverine Flood Damages
Matadero and Barron Creeks from San Francisco Bay to Foothill Expressway
Before Completion of 1988 Project

Land Use	*Area Flooded (acres)*	*Number of Buildings*	*Direct Structure Damage ($1,000)*	*Direct Content Damage ($1,000)*	*Indirect Damages ($1,000)*	*Total 1% Flood Damages ($1,000)*
Residential	1838	6873	$133,940	$76,180	$31,520	$241,640
Commercial	51	189	$8,010	$9,980	$6,300	$24,290
Industrial	32	120	$23,990	$42,110	$29,080	$95,170
Public Facilities	17	62	$2,860	$6,000	$0	$8,850
Parks	4	14	$90	$170	$0	$260
Vacant Land	1	1	$0	$0	$0	$0
Total	1943	7259	$168,890	$134,440	$66,900	$370,210

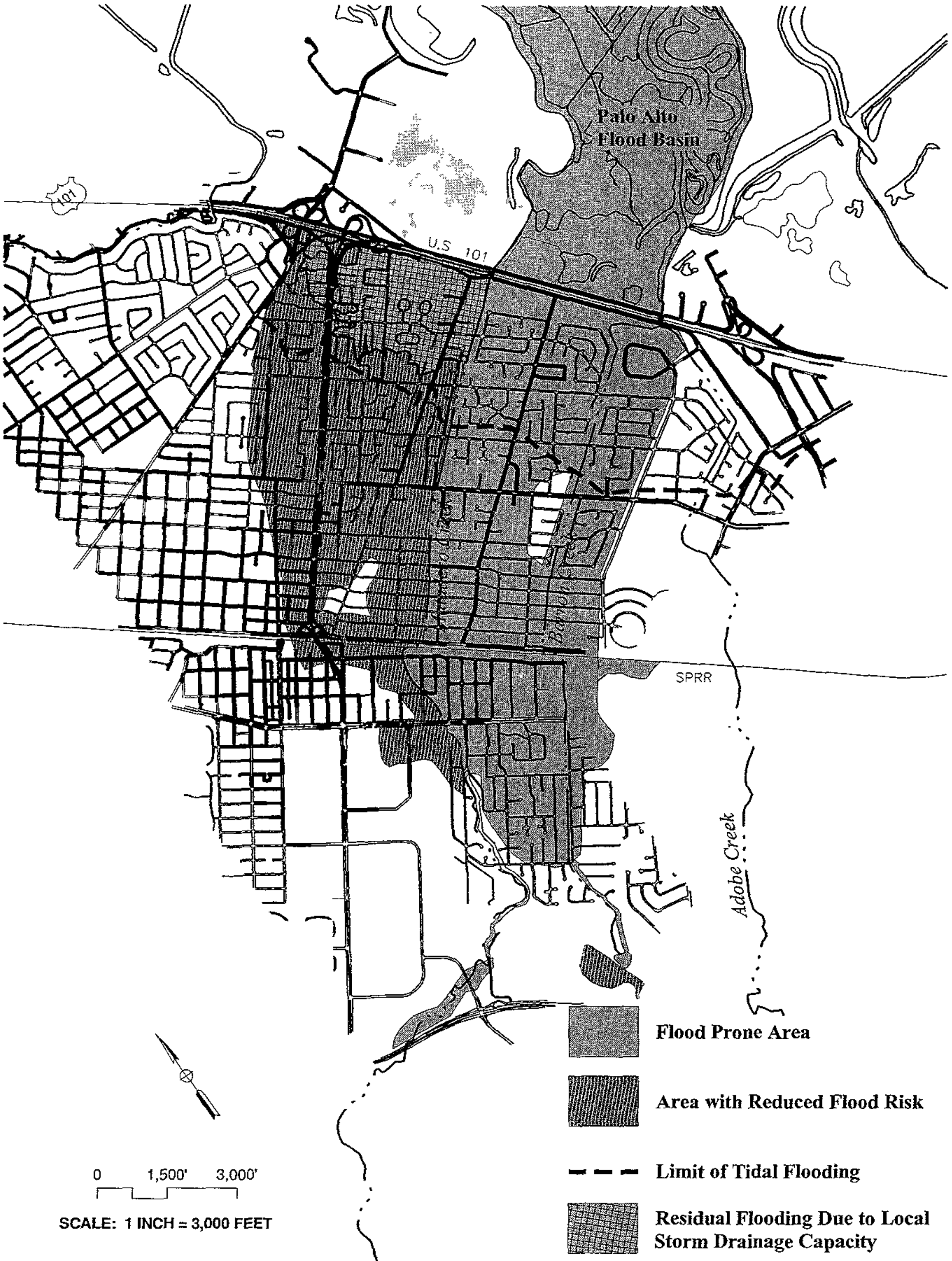
Palo Alto Flood Basin
101
U.S. 101
SPRR
Adobe Creek
Flood Prone Area
Area with Reduced Flood Risk
Limit of Tidal Flooding
Residual Flooding Due to Local Storm Drainage Capacity
0
1,500'
3,000'
SCALE: 1 INCH = 3,000 FEET

Figure 3-1. Reduction in Riverine Flood Risk Due to 1988 Project

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Table 3-2
One-Percent Riverine Flood Damages
Matadero and Barron Creeks from San Francisco Bay to Foothill Expressway
After Completion of 1988 Project

Land Use	*Area Flooded (acres)*	*Number of Buildings*	*Direct Structure Damage ($1,000)*	*Direct Content Damage ($1,000)*	*Indirect Damages ($1,000)*	*Total 1% Flood Damages ($1,000)*
Residential	1,351	5,068	$114,511	$62,970	$26,628	$204,109
Commercial	28	136	$6,864	$7,643	$5,072	$19,579
Industrial	15	100	$22,678	$39,511	$27,360	$89,549
Public Facilities	12	42	$2,500	$5,190	$0	$7,690
Parks	3	12	$80	$140	$0	$220
Vacant Land	0	1	$0	$0	$0	$0
Total	1,409	5,359	$146,633	$115,454	$59,060	$321,147

IDENTIFIED PROBLEMS BY REACH

Under the emergency operating plan, Barron Creek cannot convey its design one-percent flood discharge without flooding adjacent properties. The capacity of the 60-inch diameter pipe between Laguna Avenue and El Camino Real is exceeded by the one-percent design flood on Barron Creek. One-percent flood flows would spill out of the channel upstream from Laguna Avenue and inundate these neighborhoods. Because this pipe limits the amount of flow carried by Barron Creek downstream from Laguna, neighborhoods below El Camino Real would be at less risk to flooding from creek overtopping. The currently effective FIRM for Barron Creek or Matadero Creek would not significantly change under these conditions. Figure 3-2 provides the location of creek reaches described in this chapter.

Barron Creek

FEMA criteria on Barron Creek can be met by allowing full design diversions to Matadero Creek at Gunn High School. In areas where the one-percent flood elevation is above the natural bank, a minimum of three (3) feet of freeboard are provided. Based on District criteria, substandard channel performance is limited to a 200-foot long reach above the end of the floodwall at Louis Road, where slightly less than one foot of freeboard is provided in a non-leveed situation.

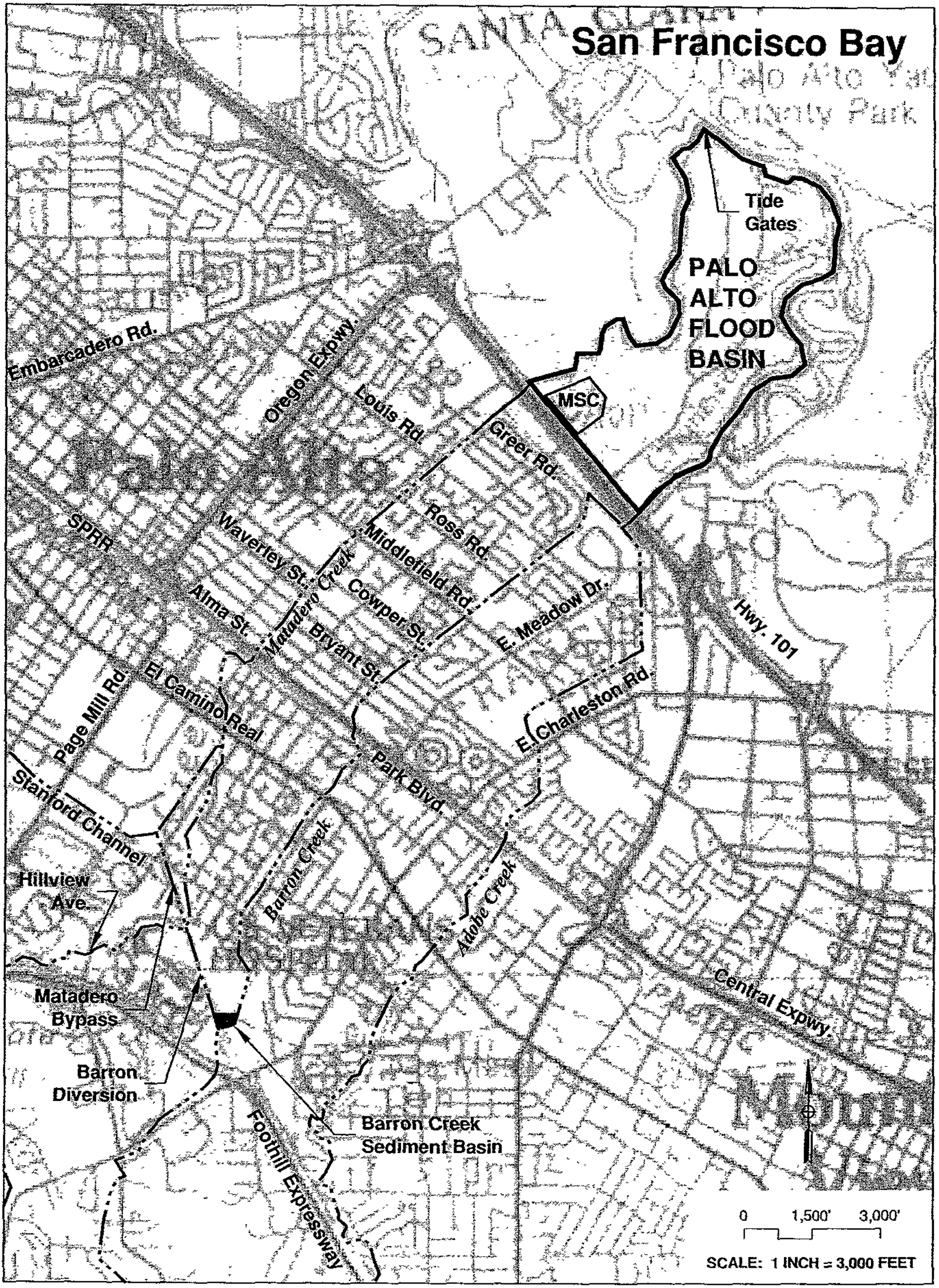

Figure 3-2 Location Map of Project Area

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Matadero Creek

Options to improve Barron Creek so that one-percent riverine flood protection is provided along Matadero Creek, without improvements to the latter, are described in Chapter 5 — "Conceptual Alternatives." The remaining paragraphs of this chapter are devoted to a discussion of identified problems on Matadero Creek itself.

Palo Alto Flood Basin. Based on analytical results from Appendix G, there is a finite risk of freshwater flooding that would overtop basin levees. Aerial surveys conducted by Towill and MacKay & Somps in April 1999 provide detailed topographic information about the levees surrounding the PAFB as well as the basin interior. Figure 3-3 shows the basin and its levees, highlighting levees that are lower than 7 feet (NGVD'29) in elevation. Some spot elevations are as low as 5.9 feet NGVD'29. Based on the 1988 Engineer's Report (5.7 feet maximum stage), and the current analysis (6.5 feet maximum stage), the margin for error during an extreme runoff event is fairly low. Assuming that the timing of when a storm begins and the times of high tides are random, the risk of levee overtopping during a design event is about one-third.

During the February 1998 event of record, District crews did not patrol the PAFB levees; therefore, no documentation is available regarding the highest stage in the basin or whether any levees were actually overtopped. The lack of identified flooding problems in the vicinity or levee erosion suggests that significant overtopping probably did not occur.

Current PAFB levee elevations do not provide adequate freeboard against overtopping, and did not provide adequate freeboard at the time of the compromise. None of the project alternatives discussed in this report will change this assessment, nor the risk of PAFB levee overtopping. With top-of-levee elevations varying from 5.9 to 8.6 feet, there continues to be a risk of overtopping along stretches of levee that are lower than 7 feet in elevation. Spilled water could inundate the Palo Alto Municipal Services Center, East Bayshore Road, and residential and commercial areas west of Bayshore Road, since a concrete median barrier on Highway 101 is discontinuous between Oregon Expressway and San Antonio Road.

Palo Alto Flood Basin to Highway 101. Downstream of Highway 101, Matadero Creek outfalls to the Palo Alto Flood Basin, but does not empty immediately into this storage facility. Rather, the creek is contained between a levee to the north and the City of Palo Alto Municipal Services Center (MSC) to the south for a distance of roughly 1,200 feet. In this reach, the creek remains channelized with a width of roughly 250 feet at the northeasterly frontage road, narrowing to a width of about 150 feet as the channel passes the northern corner of the MSC. Figure 3-4 provides a recent aerial view of this channel reach.

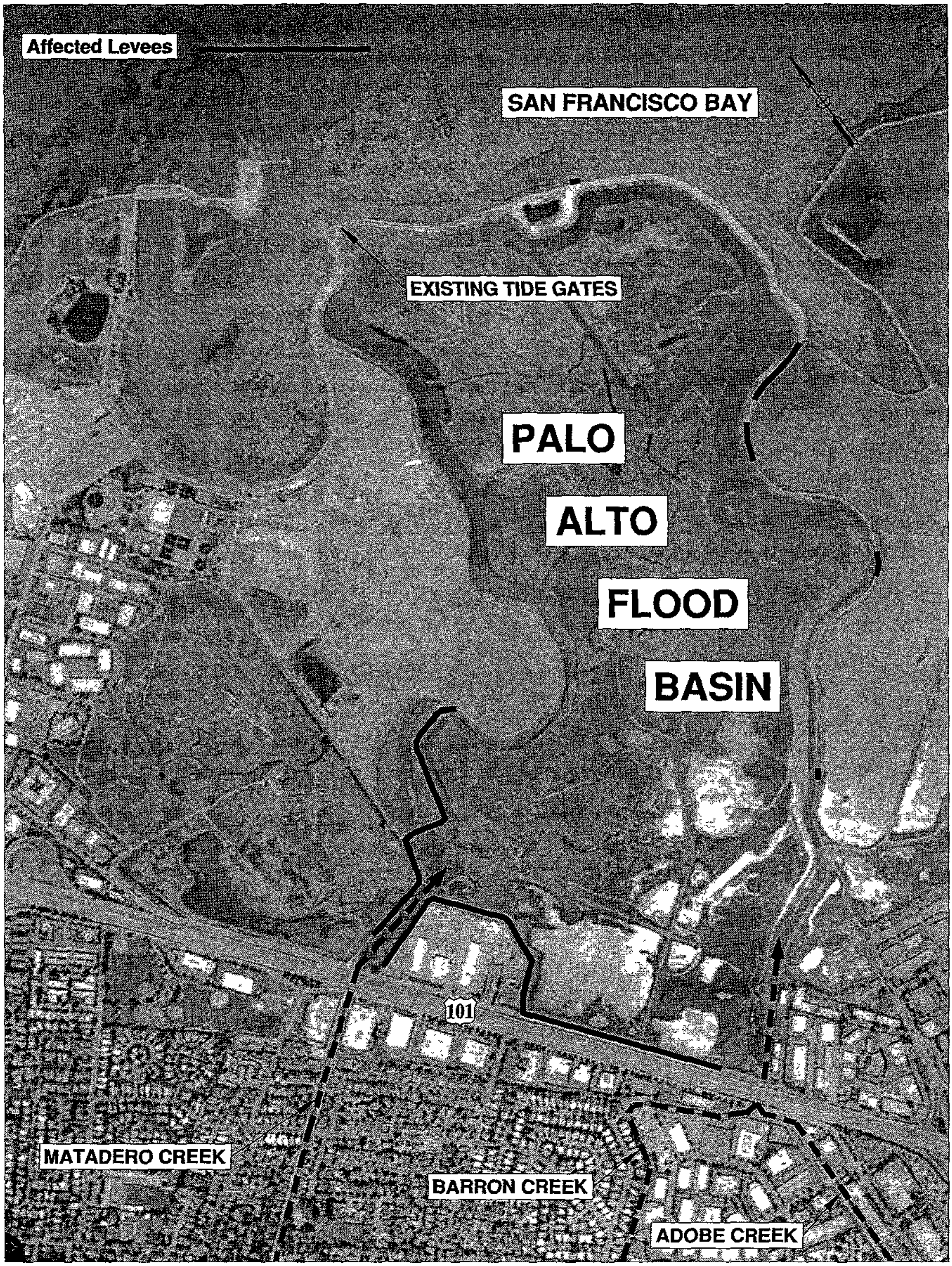

Figure 3-3. Sections of Levee around the Palo Alto Flood Basin with Elevations Less than 7 Feet

Aerial Photo by Towill Engineers, April 1999

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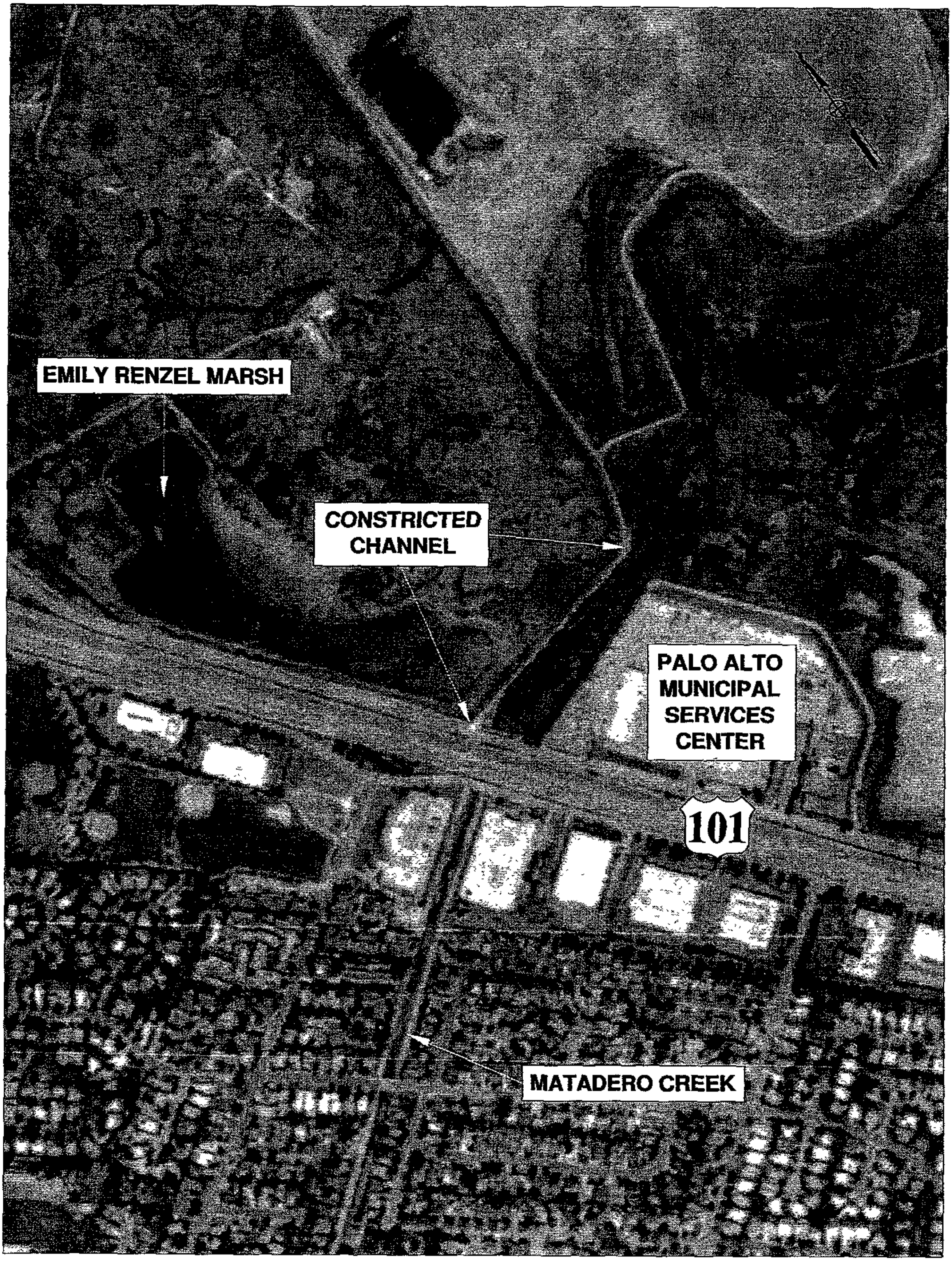

Figure 3-4. Matadero Creek Constriction Downstream of Highway 101

Aerial Photo by Towill Engineers, April 1999

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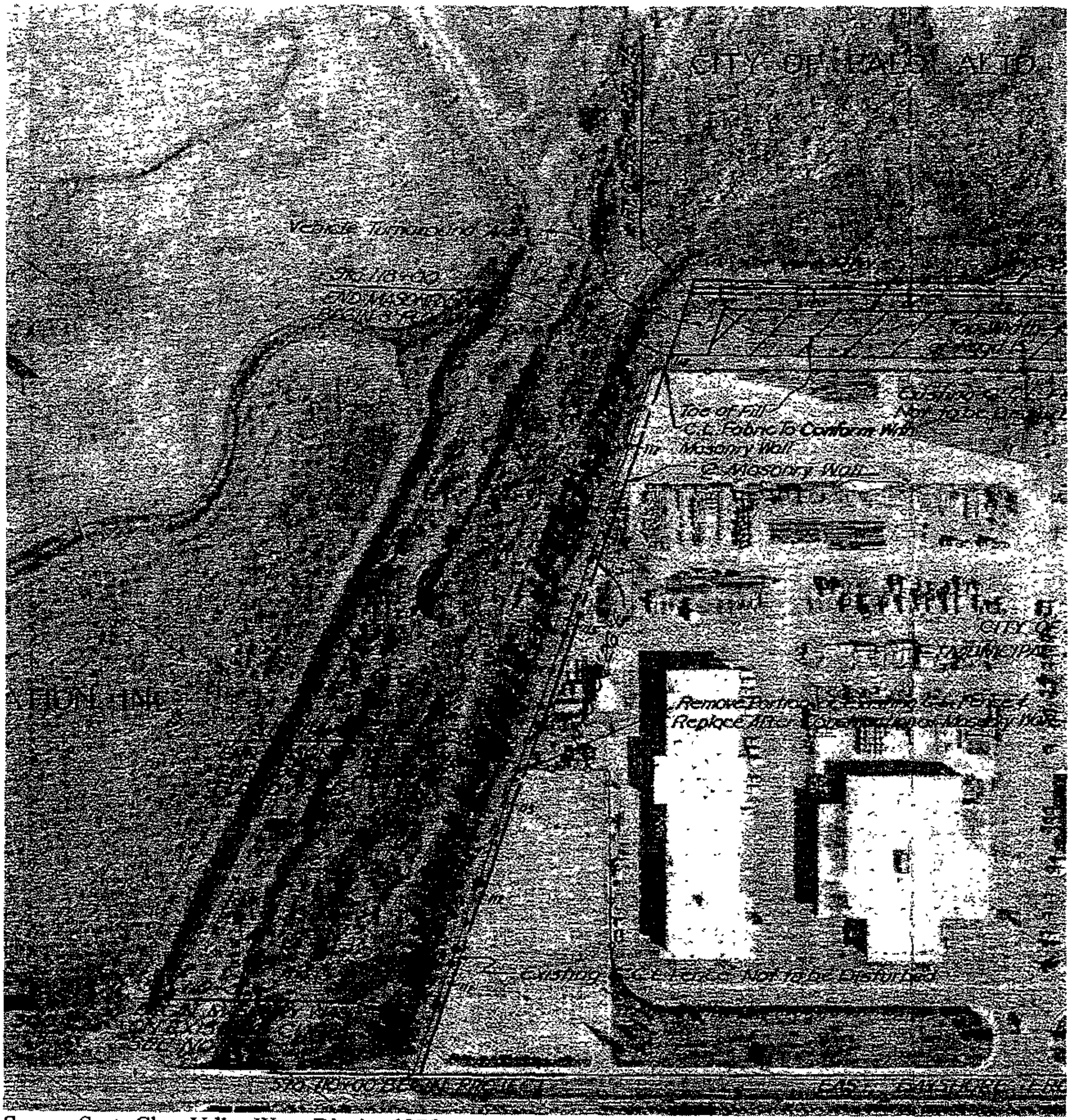
Figure 3-5 presents an aerial photograph of the same reach dated April 1971. A comparison of these two figures shows how conditions in this reach of Matadero Creek have changed over the past thirty years. Recent ground surveys reveal that while a clear channel of 20 to 25 feet in width has been maintained as recommended in the 1988 Engineer's Report, the densely vegetated banks and overbanks (see Photo 2-12) pose a much different condition than existed thirty years ago.

Without the regular removal of accumulated sediment, the constricted channel and riparian vegetation seen today have been formed by natural processes occurring between the northerly levee and the MSC. Figure 3-6 compares the current channel cross section based on July 1999 surveys to its cross section circa 1971 at the same location. Approximately 20,000 cubic yards of sediment have accumulated in the south overbank of this reach between 1971 and 1999.

Natural stream cross sections in a flat area such as this generally consist of a low flow "maintenance" channel (whose bank-full capacity is generally equivalent to about a two-year recurrence interval flow) and floodplain overbanks. Whenever the discharge exceeds the main channel's capacity and overtops its banks, the bedload of coarser sediments usually remains in the maintenance channel, while the suspended and wash loads (fine sediment particles and very fine, colloidal particles such as clay) are contained in the water within both the main channel and flooded overbank. Sediment transport within the main channel is often sufficient to maintain fine sediments in suspension, but flow velocities within the flooded overbank area can be reduced enough to cause deposition of suspended sediment and sometimes even the wash load. Vegetation growing within the rich, organic, previously-deposited sediments accelerates the depositional process by further slowing flow velocities and thus reducing the sediment transport capacity even more.

The change in cross-sectional creek area downstream of Highway 101 depicted by Figure 3-5 is the result of this natural process. Based on surveyed cross sections and field reconnaissance, it appears that the main channel has experienced relatively modest sediment aggradation, while the south overbank shows several feet of aggradation. The north bank of the channel formed by the levee protecting Renzel Marsh has also experienced some aggradation and riparian vegetation establishment. A sediment delta has begun to form where the channel discharges into the marshy flood basin at its downstream end. Deltas form when sediment-laden water is discharged into quiescent water through sudden expansions, as is the likely case at this location.


CITY OF PALO ALTO
Vehicle Turnaround Area
Sta 18+00
End Masonry
Toe of Fill
C.L. Fabric To Conform With Masonry Wall
℄ Masonry Wall
CITY OF
MUNICIPAL
Remove Portion of Existing C.L. Fence &
Replace After Construction of Masonry Wall
Existing C.L. Fence Not to be Disturbed

Source: Santa Clara Valley Water District, 1976

Figure 3-5. 1971 Aerial Photo of Matadero Creek Channel Downstream of Highway 101

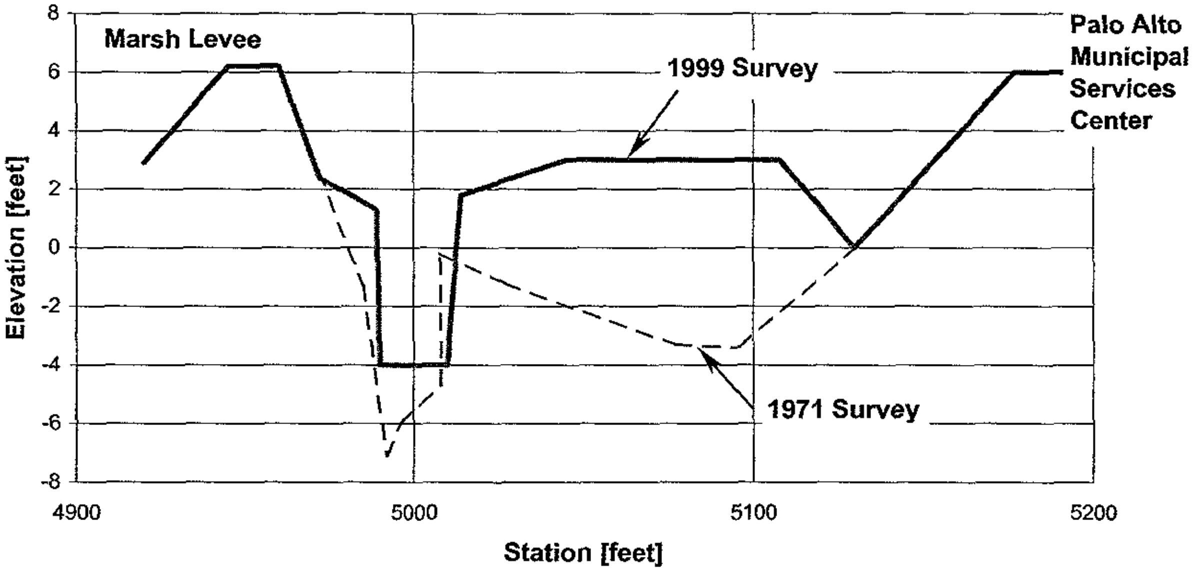


Figure 3-6. Matadero Creek 300' Downstream of Highway 101

The net effect of this natural change is twofold:

1) Areal conveyance for flood flows in excess of the two-year recurrence interval has been greatly reduced; and

2) Thick vegetation growing within the overbanks has also contributed to a reduction in flow conveyance due to increased channel roughness.

Higher water surface elevations in the Palo Alto Flood Basin, and sediment accumulation and vegetation growth within this reach, have caused the one-percent flood stage on the downstream side of Highway 101 to exceed the design flood stage considered in the 1988 Engineer's Report by over two feet. (Appendix G details calculations that support this finding.)

Highway 101 to Greer Road. Sediment has also accumulated in this reach of channel, and reedy vegetation is established on that sediment. With the current operating plan, each of the five bridges crossing the creek at Highway 101 pressurize during the peak of the design runoff event. From West Bayshore Road to Greer Road, the one-percent flood is carried above the natural ground elevation to within one foot of the top of the concrete masonry unit floodwall. This channel reach provides sufficient capacity to convey the design one-percent discharge, even with full Barron Creek diversions, without overtopping the existing floodwalls; however, freeboard meeting District or FEMA standards is not provided. Although this reach is subject to tidal flooding, and inadequate freeboard would not change the FIRM, the level of flood protection against riverine (freshwater) flooding is not equivalent to the level of protection provided in other reaches.

Greer Road to Louis Road. The concrete-lined portion of Matadero Creek begins at Greer Road. Although sediment deposition is evident within this reach of channel, it is believed that during the peak discharge of the base flood event, channel velocities (6 to 7 feet per second) would be sufficient to transport even coarse sediments to the reach below Greer Road. Channel cross sections in this reach were surveyed in 1998 after the flood of record, and include sediment deposits left during lower discharge periods. This provides for a somewhat conservative hydraulic model.

Between Greer Road and the downstream face of Louis Road, the water surface is carried above the natural bank, while available freeboard averages about two feet under the emergency operating plan. Although this channel reach provides enough capacity to convey the current one-percent discharge without overtopping, it does not provide adequate freeboard. This reach is also subject to tidal flooding. The Greer Road bridge is pressurized under design flood conditions.

Louis Road to Ross Road. At the Louis Road bridge, there is insufficient capacity to pass the design one-percent flow without causing the floodwalls to be overtopped upstream if any flow is diverted from Barron Creek. This location is projected as the first break-out point on Matadero Creek. Without diversions, the water surface is carried two feet above natural grade, and available freeboard is less than one foot just upstream of Louis Road. This reach is also subject to tidal flooding, but is at an even greater risk of overtopping during freshwater flooding events. The Louis Road Bridge is pressurized under design flood conditions.

Ross Road to Middlefield Road. At Ross Road, there is no overtopping under the existing diversion scenario, and flood levels remain just below the natural channel bank. However, with full design diversions, the water surface elevation would be at the top of the existing floodwall, and the one-percent flood elevation is above the natural ground elevations throughout the reach. Backwater from each bridge dominates the water surface profile characteristic. Although there is barely enough channel capacity within this reach to prevent overtopping, adequate freeboard is not provided.

Middlefield Road to Cowper Street. At Middlefield Road, the water surface profile is carried below the bridge soffit, and below adjacent grade, even with full diversions from Barron Creek. Thus, FEMA and District freeboard requirements are met within this reach, and there are no identified deficiencies.

Cowper Street to Waverley Street. At Cowper Street, the base flood elevation is just high enough to pressurize the bridge, if full Barron Creek diversions are allowed. Between Cowper and Waverley Streets, the one-percent water surface profile remains just at or below natural grade. This channel reach can convey the base flood without overtopping the floodwalls, but the District's freeboard standards of two-tenths of the specific energy, or one foot minimum, are not met.

Waverley Street to Bryant Avenue. At the Waverley Street bridge, the vertical channel walls would not likely be considered floodwalls by FEMA, since they do not extend above natural grade by more than about six inches. Pressurization of this bridge would result in floodwater spilling out of the channel bank with full diversions from Barron Creek. (Without diversions from Barron Creek, flood flows are contained within the channel at this location.) This channel reach does not provide adequate capacity for the base flood with full diversion, and although it can convey the base flood with less than full diversion, freeboard is inadequate through this reach.

Bryant Avenue to Alma Street. Between Bryant Avenue and Alma Street, the one-percent design flood is carried within the channel below natural grade. FEMA freeboard standards do not apply, but the existing top of wall elevations throughout this reach do not meet the District's minimum freeboard standard, which is equal to two-tenths of the specific energy head. (Channel velocities approach 13 feet per second with a depth of about ten feet; therefore, the required freeboard is at least 2.5 feet.) This channel reach provides adequate capacity, but inadequate freeboard.

Alma Street / Southern Pacific Railroad Culvert. As recommended by the 1988 Engineer's Report, the Matadero Creek channel in the vicinity of Alma Street and the Southern Pacific Railroad was realigned. This project also connected the culverts below Alma Street and the railroad together so that there is now one continuous box culvert from the downstream face of Alma Street to the upstream face at the railroad right-of-way. As shown on Photo 2-7, a local storm drainage outfall discharges next to the Alma Street culvert at the downstream face. This configuration provides for a very abrupt transition as water exits the culvert. Energy losses resulting from this abrupt transition force the culvert to perform under "outlet control" conditions. When carrying the design one-percent discharge, outlet control in the combined Alma Street / railroad culvert results in a water surface upstream of the railroad that, while carried below the top of the floodwall, is above the natural ground, with insufficient freeboard.

Southern Pacific Railroad to Park Boulevard. At the first channel bend upstream from the railroad, the water surface will become superelevated by 1.4 feet, which can be contained by the existing floodwall. At the second channel bend upstream, the superelevation is 0.5 foot, which is also contained by the existing floodwall. However, channel freeboard throughout this reach does not meet either FEMA or District standards.

If channel hydraulics are analyzed assuming a Manning's "n" value of 0.011, the reach of channel upstream of SPRR operates within the supercritical flow regime. Velocity under design conditions is on the order of 20 feet per second, and superelevations of nearly six feet are possible. Given the shallower depths with supercritical flow, the elevated water surface would still be contained by the floodwall. Just upstream of the railroad, however, the freeboard for the supercritical, superelevated condition is less than one foot. Thus, the businesses adjacent to this reach of channel could be susceptible to some overtopping due to the potential for cross-wave formation characteristic of supercritical flow.

Park Boulevard to El Camino Real. The Park Boulevard and Lambert Avenue bridges become pressurized with full diversion, but not under the temporary emergency plan. If full diversion is to be allowed under existing channel conditions, the one-percent water surface profile would be carried just below natural ground with about one foot of freeboard to the top of wall. To meet District freeboard criteria for specific energy, over 2.5 feet are required. Thus, design flows are contained within the channel throughout this reach, but additional freeboard is required to meet District criteria. FEMA criteria, however, are satisfied.

Natural Creek Channel from El Camino Real to Hillview Avenue. Discharge within this natural creek reach is the same with or without Barron Creek diversions. Hydraulic analysis shows that the one-percent flood discharge can be safely carried within the natural channel banks with at least one foot of freeboard in all locations, thus meeting District standards.

Hillview Avenue Culvert. Matadero Creek passes beneath the former Watkins-Johnson industrial property within a single-barrel 8-foot by 8-foot reinforced concrete box culvert. Due to tailwater effects on its downstream end, this culvert operates under outlet control. The resulting headwater on the culvert is not contained by the grade of Hillview Avenue, or more specifically, the grade of fill that has been placed on the southeastern side of Hillview to support industrial development. When conveying the one-percent discharge, 300 cfs will spill over Hillview Avenue, travel through the Watkins-Johnson site (which is currently being redeveloped by Stanford Management Company), and re-enter the creek at the culvert's exit. The 1988 Engineer's report recommended adding a second parallel barrel to this culvert, but this work was not completed due to the cost of hazardous material remediation and right-of-way acquisition. The entire property has been redeveloped since the 1988 study. Mapping prepared for a Conditional Letter of Map Revision (CLOMR) application to FEMA indicates that overflows can traverse the site without inundating any structures.

Hillview Avenue to Foothill Expressway. Design flows can be safely carried within this channel reach, although a depressed roadway crossing at the University Club would be overtopped. Above Foothill Expressway, approximately 130 cfs leaves the channel due to capacity restrictions at the culvert. This spill is contained within a sag in Foothill Expressway, and re-enters the natural creek channel immediately downstream of the expressway. Foothill Expressway serves as the limit of detailed hydraulic study.

Matadero Bypass. The underground concrete bypass between the Barron Creek diversion and El Camino Real has sufficient capacity to accommodate the one-percent design flow, including full diversion from Barron Creek.

Summary

Table 3-3 summarizes identified channel deficiencies for Barron and Matadero Creeks, under the assumption that full diversion from Barron Creek to Matadero Creek is restored. Under the emergency operating plan, Matadero Creek provides 100-year protection without freeboard. According to District officials, Barron Creek provides protection from at least a 20-year runoff event, and depending upon the relative timing of runoff from each watershed, up to the 100-year runoff event.

Table 3-3
Matadero/Barron Creek Hydraulic Deficiencies

Reach	*Identified Deficiencies*
Barron Creek	minor freeboard violation
Barron Creek Diversion	none
Matadero Creek:	
Downstream Highway 101	limited flood flow capacity
Highway 101 to Greer Rd	inadequate FEMA/District freeboard
Greer Rd to Alma St	inadequate FEMA/District freeboard overtopping at Louis and Waverley
SPRR to El Camino Real	inadequate District freeboard
El Camino Real to Bypass	none
Bypass to Foothill	overtopping at Hillview Avenue, University Club and Foothill Expressway
Matadero Bypass	none

CHAPTER 4
FORMULATION OF REMEDIATION ALTERNATIVES

INTRODUCTION

This chapter introduces the process by which alternative remediation projects that could alleviate performance deficiencies described in Chapter 3 are formulated and evaluated. First, a broad range of conceptual solutions that meet project objectives are identified. These conceptual alternatives are screened for feasibility in Chapter 5. Those alternatives that are considered to be feasible are evaluated further in Chapter 6 at a higher level of detail. From this second level of evaluation, a project recommendation is made in Chapter 7.

Based on the identification of problems described in Chapter 3, the following channel reaches and facilities require remediation to provide one-percent flood protection meeting NFIP and District standards:

1) The designed 600 cfs diversion from Barron Creek to Matadero Creek must be fully functional to prevent flooding between El Camino Real and Laguna Avenue along Barron Creek.

2) Matadero Creek between the Palo Alto Flood Basin and Highway 101 has insufficient capacity to convey the one-percent flood without spilling into the City of Palo Alto Municipal Services Center.

3) Between Highway 101 and Alma Street, the Matadero Creek channel has insufficient capacity to convey the one-percent flood with adequate freeboard. In addition, during the one-percent design runoff event, flood flows would overtop channel walls upstream of the Louis Road and Waverley Street bridges.

4) Between the Southern Pacific Railroad and El Camino Real, available freeboard does not meet District standards on Matadero Creek.

Correcting identified deficiencies upstream of El Camino Real, including spills at Hillview Avenue, the University Club road crossing, and Foothill Expressway are not part of this remediation project.

SCREENING OF CONCEPTUAL ALTERNATIVES

As was the case in the 1988 planning study, physical realities, the regulatory environment, maintenance activities, and community concerns limit the types of projects that can be brought to fruition. Projects must balance hydraulic performance against several constraining issues. Listed below are the fundamental project constraints used to screen potential conceptual remediation projects for feasibility in Chapter 5.

Flood Protection

District policy is to provide protection against the one-percent flood in accordance with NFIP policies. A conceptual alternative must provide protection against flooding from a design one-percent riverine event to be considered feasible. Protection against tidal inundation or flooding from San Francisquito Creek are not addressed by this project.

Environmental Impact

All potential remediation projects are subject to compliance with the California Environmental Quality Act (CEQA). The Draft Environmental Impact Report (DEIR) for the Matadero and Barron Creeks Remediation Project is bound together with this document. The DEIR contains detailed descriptions of relevant environmental regulations and policies, and evaluates project alternatives against those regulations and policies. Project alternatives with excessive adverse impacts (relative to other conceptual alternatives) do not meet the District's objective of protecting the environment in the formulation and execution of its programs and projects, and are not considered feasible.

Project Cost

A total of $24 million has been allocated for planning, permit acquisition, engineering, construction, inspection, mitigation, and administration. Of these funds, $2 million has been spent for planning, leaving $22 million for project completion. A reasonable increase in project cost may be acceptable, if an alternative plan has significantly less adverse impacts and strong public support. For the purposes of alternative screening, a doubling of project cost to roughly $40 million has been established as the order-of-magnitude cost criterion for alternative feasibility.

In Chapter 5, these three major criteria are used to compare and screen conceptual alternatives. Those alternatives that appear to be feasible are carried forward for additional evaluation using a second layer of evaluation criteria.

EVALUATION OF FEASIBLE ALTERNATIVES

In Chapter 6, additional criteria are used to evaluate those feasible project alternatives that have passed through the screening process in Chapter 5. The level of project detail has increased, and more criteria are used in the evaluation process. Two of the three fundamental criteria used to screen concepts for feasibility — environmental impact and project cost — are repeated at this level of evaluation, but with greater scrutiny.

Any project alternative that passes forward to this level of evaluation meets the project objective of providing one-percent flood protection. However, differences in environmental impact, project cost, schedule, maintenance, and so forth, may begin to separate feasible alternatives from one another in terms of cost effectiveness and public acceptance. These differences are documented in Chapter 6 and used as a basis for the recommended capital improvement program described in Chapter 7. Readers are, however, encouraged to consider all project alternatives in comparison to the recommended plan.

Environmental Impact

Projects reaching this level of consideration do not have adverse environmental impacts that cannot be mitigated. In addition to CEQA compliance, feasible alternatives may require permits from various jurisdictional agencies for construction and operation. While the Engineer's Report does not address specific permit requirements, Section 404 guidelines specify that projects should be formulated to avoid impacts, and if this is not possible, to minimize and compensate for those impacts. Consequently, professional biologists, herpetologists, ornithologists and mammalogists have been consulted to evaluate potential adverse impacts to wildlife habitat caused by the implementation of feasible alternatives. Based on these professionals' judgement and experience with permits for similar projects, necessary mitigation measures are recommended to compensate for environmental impacts. Mitigation typically involves the creation of habitats equivalent in nature to habitats disturbed by the project. Depending upon the type of disturbance and the relative difficulty of recreating that habitat elsewhere, mitigation areas are typically provided at some ratio to the area of impact. For instance, permits may require that two or three acres of new habitat be created for every acre of habitat adversely impacted by a project.

Projects with less environmental impact and requisite mitigation may be more favorable than those alternatives requiring greater impact and mitigation. District policy is to minimize the adverse environmental impacts of its projects. Considering the cost of mitigation itself, and the cost of land for mitigation areas, minimizing environmental impacts may be cost effective.

Table 4-1 summarizes many of the environmental regulations and policies evaluated for feasible alternatives, and lists permits that may need to be obtained depending upon the nature of a proposed project.

Table 4-1
Environmental Regulations

Regulation	*Jurisdictional Agency*
Clean Water Act	U.S. Army Corps of Engineers
Endangered Species Act	U.S. Fish and Wildlife Service
Fish and Wildlife Coordination Act	U.S. Fish and Wildlife Service
Executive Order 11990 (wetlands)	
California Endangered Species Act	CA Department of Fish and Game
Bay Area 1997 Clean Air Plan	Association of Bay Area Governments
San Francisco Bay Basin Plan	Regional Water Quality Control Board
Santa Clara Valley Urban Runoff Pollution Prevention Program	Environmental Protection Agency
San Francisco Bay Trail	
Santa Clara Valley Water District Environmental Policies	Santa Clara Valley Water District
Palo Alto Comprehensive Plan	City of Palo Alto

Project Cost and Schedule

Alternatives that pass the initial conceptual screening process will have similar order-of-magnitude costs. For the second-level evaluation of feasible alternatives, project cost estimates are refined to include construction, engineering, land acquisition, mitigation, and the present worth of annual maintenance. This refinement allows comparative project costs to become one important factor in the selection of a recommended capital improvement program.

Community Concerns

Specific reactions from members of the community to previously presented project alternatives are included in the evaluation of feasible alternatives. Alternatives for which the public has expressed general support can be more appealing than other alternatives, all other evaluation criteria being relatively equal.

Between June 1999 and February 2000, a series of three public meetings were held to present the proposed project plan to the public. An informational workshop was also held during this time for those members of the public who wished to learn of the detailed hydrologic and hydraulic analyses that were performed for this planning study. The first public meeting provided an overall history of the project and the findings to date regarding the channel inadequacies for conveying the one-percent event. The second public meeting specifically focused on the Matadero Creek channel constrictions downstream of Highway 101, and provided detailed descriptions and impacts of the possible project alternatives in this reach. The recommended project was presented at the third public meeting. Approximately 60 persons attended each meeting.

Between December 1999 and July 2000, District and consultant staff held three small group meetings for representatives of various environmental and citizen groups interested in the project. The represented groups included the Audubon Society, the Santa Clara Native Plant Society, Bay Area Action, Committee for Green Foothills, and Streams for Tomorrow. The purpose of these meetings was to provide more details on the anticipated environmental impacts from the feasible project alternatives and solicit input from those who attended. The information and concerns exchanged during these meetings were very helpful to both project staff and the participating citizens.

District and consultant staff met with representatives from Stanford University three times between September and December 1999 to discuss the use of Stanford lands for an off-stream storage alternative. District and consultant staff also met with City of Palo Alto staff every three or four months during the alternatives analysis phase of the planning study to apprise City staff of the findings to date and discuss the impacts of feasible alternatives in the reach of Matadero Creek between Highway 101 and the Palo Alto Flood Basin on City operations at their Municipal Services Center.

The City of Palo Alto Comprehensive Plan specifically addresses flooding and endorses active participation in the National Flood Insurance Program:

> "Urban development has encroached on the natural floodplains and floodways in the flatlands and Baylands. It is not feasible to remove existing development from flood hazard areas, but precautions can be taken in the further development of those sites to minimize the potential for damage from floodwaters. Such precautions would include channels, retention basins for floodwaters, and elevation of structures."

Rights-of-Way

Real estate in Silicon Valley is at a premium. Project alternatives that require additional land for project facilities or mitigation sites could be at a distinct disadvantage in terms of capital cost relative to projects that can be built within District rights-of-way or easements.

Utility Conflicts

Below Foothill Expressway, Matadero and Barron Creeks run through mature urbanized areas with a full complement of underground and overhead infrastructure. In particular, the north bank of Matadero Creek hosts several major utilities, including two underground high-voltage electrical transmission lines, a sanitary sewer, and a buried communications cable. Other utilities such as water, sewer, natural gas and electricity cross the creek right-of-way at many locations, particularly at roadway crossings. The San Francisco Water Department's Hetch-Hetchy Aqueduct crosses Barron Creek near the sediment basin at Gunn High School. Projects involving major modification to existing facilities will likely require existing utilities to be relocated or protected during construction.

Geotechnical Considerations

Geotechnical investigations have been conducted as part of this planning study (Lowney Associates, 2001). Underground conditions along the Matadero Creek channel may profoundly affect the selection of a recommended_project. -Primary geotechnical concerns include the influence of groundwater on the design and construction of improvements, the support of temporary excavations during construction, and the presence of moderately to highly expansive soils. Depth to groundwater after Spring 1999 ranged from 4 feet to 11 feet in the project vicinity, which could complicate construction given the fact that the channel invert is roughly ten feet below existing grade. Due to limited right-of-way within the project area, excavation support will be necessary during construction excavation for various potential improvements to prevent damage to existing structures and facilities. Certain geotechnical and structural considerations will also need to be addressed to accommodate the expansive nature of the native soil upon which project improvements will be founded.

Hazardous Materials

Project alternatives that minimize or avoid construction within contaminated soils could be at an advantage in terms of construction cost and schedule. Based on a Phase I Environmental Site Assessment (Lowney Associates, 2001) and previous groundwater and soil contamination sites identified in the 1988 Initial Study/Negative Declaration, hazardous material contamination near project locations has been encountered adjacent to the City's Municipal Services Center (petroleum hydrocarbons); and may be encountered near the Pacific Gas and Electric switching station just upstream from Highway 101 (hazardous materials usage information is unavailable); a service station located at Middlefield Road in use since 1972 (petroleum hydrocarbons); and the Watkins-Johnson site at Hillview Avenue (TCE, TCA, and other compounds).

Two steel-jacketed high-voltage power lines encased in cooling oil are present along the north bank of the Matadero Creek channel. The cooling oil reportedly does not contain PCBs, but the oil does not have secondary containment. Although a leak detection program is in place and there have been no reported leaks in the history of these cables, there is always the possibility of soil and groundwater contamination should the cables be disturbed during construction.

Structural Considerations

Each feasible project alternative considered in this planning study would require design within the realm of generally accepted structural engineering practices. Several structural engineering issues, however, may affect the evaluation of alternative approaches to remediation. These issues include the raising of floodwalls, uplift on bridges due to pressurization, and likely construction techniques. Each of these issues is expanded upon in the discussion of feasible alternatives as appropriate.

ANCILLARY EVALUATION CRITERIA

If by using the aforementioned criteria through the CEQA process, two or more feasible project alternatives appear to be equally attractive, the following ancillary issues could weight a program recommendation toward one particular alternative over another.

Sediment Management and Channel Maintenance

Sediment originating from the upland areas of the Matadero and Barron Creek catchments is transported down the natural and concrete channels and is deposited wherever sediment transport capacity diminishes relative to upstream transport. Upland sedimentation was of sufficient concern that the Barron Creek sedimentation basin was constructed, although there is no similar facility on Matadero Creek. Sediment deposition could potentially increase maintenance costs for any project, so the most attractive alternatives are those that reduce scour and deposition, and promote the ability to remove sediment deposits from the channel as necessary. Since channel maintenance is required no matter which project alternative is selected, the ease and cost of maintaining project facilities are considerations in the selection of a recommended project.

Local Drainage

Adjacent areas of Palo Alto rely upon both Matadero and Barron Creeks to provide outfalls for the city's local storm drainage collection systems. The alluvial formation of Matadero Creek and land subsidence have aggravated local drainage conditions, particularly downstream in the area of tidal influence. Surrounding neighborhoods are often at a lower elevation than the natural channel bank; therefore local runoff from these neighborhoods cannot always drain by gravity into the creeks. To alleviate this condition, the City of Palo Alto operates a pumping facility that drains both sides of Matadero Creek from Highway 101 to the vicinity of Ross Road. Several other storm drain outfalls between Ross Road and Alma Street are also ineffective during high flow conditions. While one-way flapgates installed on these outfalls prevent creek water from draining to the neighborhoods, they do not change the basic gravity drainage problem. All other factors being equal, alternatives that improve the local drainage situation are more attractive than those that do not.

FEMA REGULATIONS

All project alternatives are intended to provide flood protection in accordance with the policies of FEMA's National Flood Insurance Program and District standards.

COORDINATION WITH OTHER FLOOD PROTECTION PROJECTS

Flood basin levees are not currently certified to FEMA standards because adequate freeboard against the one-percent tide is not provided. There are no immediate plans to bring this levee system into conformance with the national standard. Federal regulations (NFIP §65.10) specifically state that FEMA will only recognize those levee systems that meet, and continue to meet, its minimum design, operation, and maintenance standards. Consequently, areas currently mapped within the one-percent tidal floodplain will remain so mapped. Similarly, inadequate capacity within San Francisquito Creek results in a residual floodplain adjacent to the north bank of Matadero Creek that will not be eliminated by this project. However, remedial work for Matadero and Barron Creeks must function within an ultimate comprehensive plan designed to reduce the overall risk of flooding from all sources (riverine and tidal) within Palo Alto. Remediation must still meet project objectives once residual tidal and San Francisquito Creek flooding are eliminated.

CHAPTER 5
CONCEPTUAL ALTERNATIVES

Conceptual alternatives to meet basic project objectives are formulated and evaluated in this chapter. Alternatives are examined in a broad sense, using the three fundamental screening criteria established in Chapter 4: one-percent flood protection; potential environmental impacts; and reasonable project costs. Those alternatives that pass this comparative screening process are identified as feasible alternatives meeting basic project objectives, and are suitable for further development as discussed in subsequent chapters.

Four basic options are available to the District, the latter three of which can correct identified deficiencies in the Matadero and Barron Creek system:

1. Do Nothing (No Project); or
2. Store Surplus Runoff in Excess of Available Conveyance; or
3. Divert Surplus Runoff Around the Existing System; or
4. Increase System Conveyance.

Non-structural solutions that would not involve channel modifications or the construction of other flood protection facilities are also explored as an adjunct of the No Project alternative.

"NO PROJECT" ALTERNATIVE

While this alternative does not meet project objectives, a description of the flooding situation without project action must be included with environmental documentation for any recommended remediation plan.

Description of Alternative

Under this scenario, the present emergency operating plan that does not increase the risk of flooding along Matadero Creek would continue indefinitely. A full description of the emergency operating plan was provided in Chapter 3. No construction or other capital improvements would take place. Present maintenance practices would continue.

Alternative Screening

The "No Project" Alternative has been evaluated using the three fundamental criteria for conceptual alternatives:

Flood Protection. The emergency operating plan does not provide for one-percent flood protection meeting NFIP standards along Matadero and Barron Creeks. While the risk of flooding along Barron Creek is substantially reduced relative to pre-1988 project conditions, diversion of flood flows from Barron to Matadero can only take place if conditions in the Matadero Creek channel make it safe to do so. The "No Project" alternative provides a greater level of flood protection along Matadero Creek than along Barron Creek. Figure 5-1 shows the residual floodplain remaining under the "No Project" alternative. Increased flood protection benefits have been provided to the north of Matadero Creek, but not to the south.

Continued emergency operation does not allow for full design diversion of flow into Matadero Creek, leaving one-percent flood discharges in Barron Creek that exceed the pipe capacity at Laguna Avenue. Under this project alternative, no action would be taken on Matadero Creek between the Palo Alto Flood Basin and Alma Street. The Barron Creek diversion would be operated so that flood risk on Matadero Creek is no greater than under pre-1988 project conditions. (If necessary, there would be no flow at all diverted from Barron Creek.) Plate 1 provides a water surface profile for the "no project" alternative. While one-percent floodwaters do not overtop the existing floodwalls upstream of Highway 101, the water surface is carried above the natural channel bank between Greer Road and Ross Road. Less than one foot of freeboard is afforded just upstream Louis Road. Downstream of Highway 101, floodwaters spill over the southerly creek bank into the Municipal Services Center.

Since the reach of Matadero Creek with inadequate freeboard downstream of Ross Road is within the mapped one-percent tidal flooding zone, the current flood hazard map presented in Figure 2-5 is not affected. Homeowners and businesses residing in the one-percent floodplain, where flood depths are one foot or greater, would still be required to purchase flood insurance through the NFIP. Since the goal of this remediation work is to provide a level of flood protection consistent with NFIP standards, the "no project" alternative cannot meet this objective.

Because FEMA and District freeboard criteria are not satisfied on Matadero Creek downstream of Ross Road, a residual floodplain would remain even when future bayland levee improvements are completed to remove the mapped one-percent tidal flooding hazard area. The freeboard problem that is somewhat masked by the tidal flood hazard zone mapped in the area would no longer be masked once the burden of mandatory flood insurance purchases is lifted by future levee improvement projects.

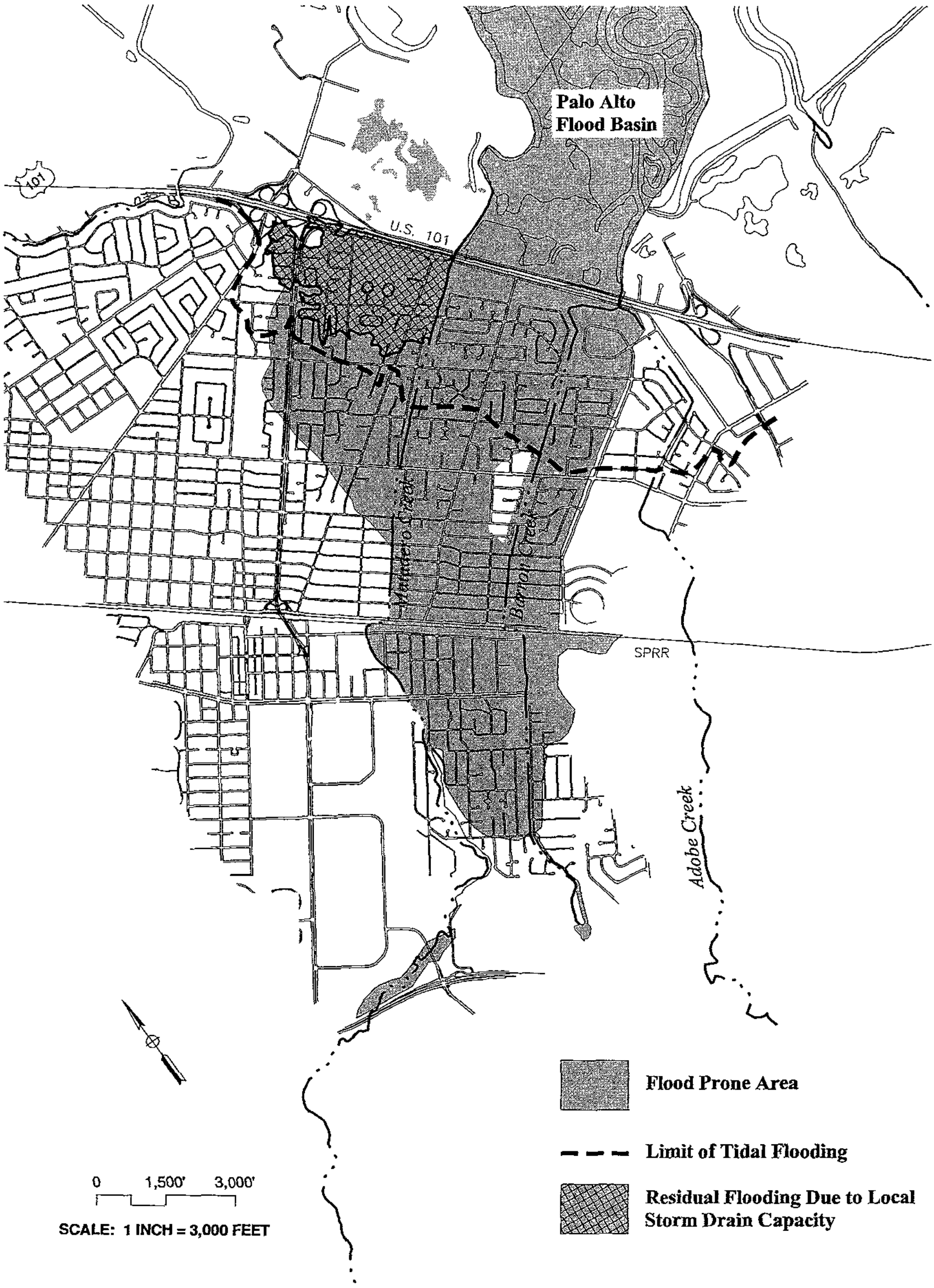


Figure 5-1. Riverine Flood Risk after 1988 Project

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Environmental Impacts. Without a project, there are no significant impacts to biological resources. Riparian and wetland habitats below Highway 101 would experience no deleterious effects. Areas of hazardous material contamination adjacent to the MSC would not be disturbed.

Project Costs. Economic costs are associated with a "no project" alternative. The present worth of annual flood damages prevented by a remediation project, estimated to be about $1.9 million per year, is $31 million. Insurance premium costs to the owners of the 470 structures that would remain covered by the program in lieu of a project are $300,000 annually. The present worth cost for this coverage over the 100 year project life is $5 million.

Alternative Feasibility

The "No Project" alternative is not feasible because it fails to provide one-percent flood protection on Matadero and Barron Creeks meeting NFIP and District standards.

NON-STRUCTURAL ALTERNATIVES

A non-structural alternative would minimize flood damages to structures in the floodplain without channel modifications, upstream storage, or upstream diversion. Non-structural options include the removal of structures from a floodplain or flood-proofing structures within the floodplain.

Description of Alternative

Although listed as a "non-structural" alternative, flood-proofing involves structural measures taken by individual property owners. These measures could include a combination of rebuilding structures on earthen fill above the floodplain; lifting structure on columns above the floodplain; constructing floodwalls or berms around individual properties and installing pumps to handle interior drainage; or building flood shields, closures, and ~~flood~~ warning systems.

Alternative Screening

Non-structural alternatives have been evaluated using the three fundamental criteria for conceptual alternatives.

Flood Protection. The flood hazard map in effect would not change, but individual property owners could be relieved of the need to purchase flood insurance once their flood-proofing measures are certified. Flooding could still occur, especially along Barron Creek, with the potential for disruptions to emergency services during flood events and damage to landscaping and ancillary structures that are not flood-proofed.

Environmental Impacts. With a non-structural solution, there are no significant impacts to biological resources. Riparian and wetland habitats below Highway 101 would experience no deleterious effects. Areas of hazardous material contamination adjacent to the MSC would not be disturbed. The impact of flood-proofing measures would be limited to individual properties which are already developed and not considered to be riparian or wetland habitat.

Project Costs. Removing 3,500 structures from the freshwater floodplain that remained after the completion of the 1988 project would cost more than $2 billion. Costs to flood-proof 3,500 structures are estimated to exceed $250 million. Neither approach is considered to be within the range of feasible project cost. Detailed cost estimates are provided in Appendix E.

Alternative Feasibility

This alternative is considered infeasible and impracticable due to the high cost of flood-proofing structures or removing structures from the floodplain. Non-structural approaches to flood protection do not address or solve continued impacts from creek overflows including street flooding and ponding, non-structural damages or the mapping of flood hazard areas. The social impact of relocating families and/or removing homes is significant, and full public participation would be difficult to achieve. Finally, in response to several community inquiries regarding District responsibility for flood insurance premiums, it is District policy to provide one-percent flood protection rather than assume liability for flood insurance premiums.

STORAGE ALTERNATIVES

Conceptual storage alternatives would reduce the design discharge conveyed by the system and thus eliminate the need for channel remediation. Creek discharges can be reduced by providing storage that retains or detains a certain volume of flow. To eliminate the need for Matadero Creek or Barron Creek channel improvements (the latter of which requires full diversion to Matadero Creek), system discharges need to be reduced on the order of 1,100 cfs at Alma Street, (from 2,800 cfs to 1,700 cfs) which is roughly equivalent to the 10-percent flood.

Three storage alternatives are available for consideration, as described herein:

- Construction of an upstream reservoir;
- An off stream storage facility at the upstream end of the system (Stanford); and
- An off stream storage facility at the downstream end of the system (Renzel Marsh).

UPSTREAM RESERVOIR ALTERNATIVE

Building a dam on either Matadero or Barron Creeks, or one of its tributaries, is one method of providing flood protection storage. However, an upstream reservoir within the Barron Creek watershed is not feasible because such a facility cannot be located to control a drainage area sufficient to reduce downstream discharges and meet project objectives. Even without diversions to Matadero Creek, the lower reaches of Matadero Creek are exposed to higher levels of flood risk relative to other reaches of Matadero Creek due to inadequate freeboard. Thus, even if all of Barron Creeks upstream runoff is captured by a reservoir, inequitable flood risk along downstream reaches of Matadero Creek is not alleviated.

Description of Alternative

A 1957 District project to construct a water supply reservoir in the Matadero Creek canyon upstream from the confluence with Deer Creek has been re-examined in the context of a flood protection project. To reduce the one-percent discharge at Alma Street to 1,700 cfs while providing for the maximum 600 cfs diversion from Barron Creek, the one-percent flowrate at the reservoir location cannot be greater than 150 cfs. With the one-percent inflow hydrograph at this location, a 600 acre-foot flood control reservoir is required. (See Figure 5-2 for the conceptual dam and reservoir site.)

Alternative Screening

The Upstream Reservoir Alternative has been evaluated using the three fundamental criteria for conceptual alternatives:

Flood Protection. By reducing downstream discharges on Matadero Creek, protection against one-percent riverine flooding would be provided along Matadero and Barron Creeks from Foothill Expressway to San Francisco Bay.

Environmental Impacts. The conceptual dam shown on Figure 5-2 would be approximately 1,000 feet long, with a toe to crest height of 100 feet. The reservoir created by this impoundment would inundate roughly 60 acres during a design one-percent event. This alternative would flood the stream corridor environment for nearly a mile, but it does not appear that any homes would need to be relocated. Interstate 280 would be flooded at the Page Mill Road interchange, so the freeway interchange would need to be partially relocated toward the south on higher ground. Page Mill Road would need to be relocated above the elevation of the dam's emergency spillway (0.5 miles of road work). Old Page Mill Road, which would be completely inundated by the reservoir, provides access to homes above the western shore. A replacement road would need to be built above the reservoir. Short-term environmental impacts include noise, dust, and air pollution from blasting operations for the dam foundation, construction of the dam itself, and reconstructing the freeway interchange.

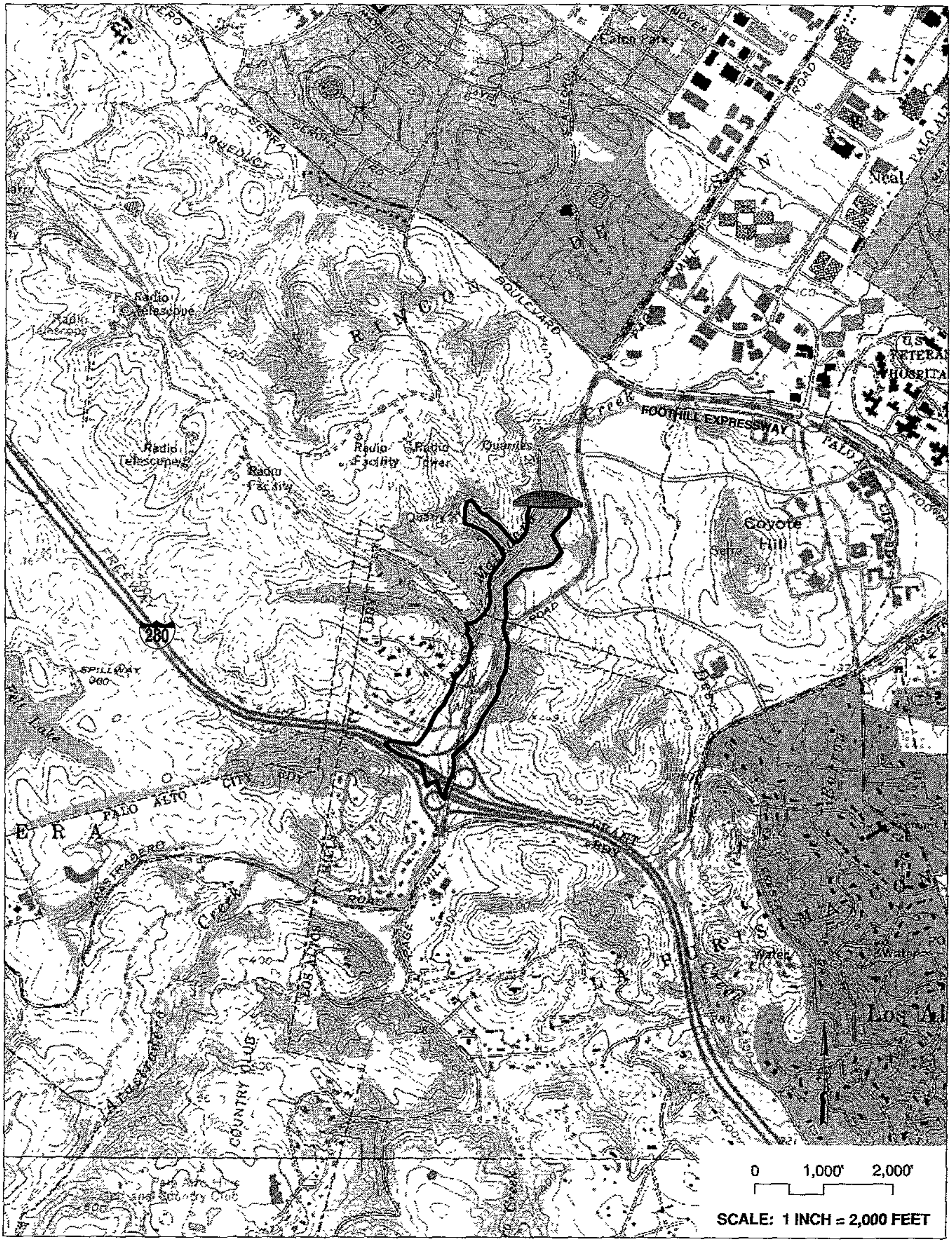

Figure 5-2. Upstream Storage Reservoir Site

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The impoundment of streamflow in the upper reaches of Matadero Creek would have environmental consequences. Sediment would become trapped behind the dam, changing the stream's geomorphology both upstream and downstream of the reservoir. Upstream effects of a reservoir could include delta formation (similar to Searsville Lake on the adjacent San Francisquito Creek watershed), a gradual raising of stream levels in the backwater zone, and additional stream bed meandering. Initial downstream impacts could include increased bed scour and bank degradation.

Maximum peak reservoir releases for this alternative are limited to a relatively minor 150 cfs. For an order of magnitude comparison, the peak annual discharge at the Matadero Creek gage (which does include a larger watershed) has exceeded 150 cfs every year for 37 of the past 45 years. Diminishing average annual flows in the creek could have a significant and unavoidable impact to the natural stream environment between the reservoir and El Camino Real.

For the purpose of estimating an order-of-magnitude environmental mitigation cost, it is assumed that a 50-foot riparian corridor 4,500 feet long would be lost under this alternative. The loss equates to 5 acres of riparian habitat, which would likely be mitigated at a 3:1 ratio, resulting in 15 acres of mitigation.

Project Costs. Table 5-1 provides a summary of estimated capital costs for this conceptual alternative, assuming adequate mitigation acreage could be found. Reservoir construction costs are estimated in Appendix E.

Table 5-1
Estimated Project Costs for Upstream Reservoir Alternative

Project Element	*Estimated Cost*
Construction	$25,000,000
Mitigation Work	$3,000,000
Land Acquisition for Reservoir	$20,000,000
Land Acquisition for Mitigation	$15,000,000
Contingencies	$17,000,000
TOTAL COST	**$80,000,000**

Alternative Feasibility

Upstream reservoir construction is not feasible due to its high cost and substantial environmental impacts to the Matadero Creek corridor. The cost of this conceptual alternative is two times the limit of feasibility. Over half of the project cost is associated with land acquisition for the impoundment and mitigation.

STANFORD STORAGE ALTERNATIVE

A smaller off-stream storage facility that would reduce Matadero Creek flows by 600 cfs has been formulated as another upstream storage alternative. This alternative reduces some of the environmental impacts posed by the previous alternative, particularly the low-flow regime along Matadero Creek.

Description of Alternative

Figure 5-3 presents a conceptual schematic for a 130 acre-foot detention basin located on a 20-acre site near the intersection of Foothill Expressway with Page Mill Road on Stanford University land (Photo 5-1). During high flow events, water from Matadero and Deer Creeks would overflow through a spillway structure into an excavated holding pond for detention and eventual release back to Matadero Creek once the peak of the flood wave has passed.

Flood protection facilities required for this concept include an excavated basin, two overflow spillways at Matadero Creek (Page Mill Road) and Deer Creek (Coyote Hill Road), and a return-flow drain back to Matadero Creek just upstream from Foothill Expressway. Since a berm or dike is not required for this impoundment, the facility would not be classified as a dam.

Alternative Screening

The Stanford Storage Alternative has been evaluated using the fundamental screening criteria for conceptual alternatives.

Flood Protection. By reducing one-percent discharge in Matadero Creek by 600 cfs, full design flow diversions from Barron Creek into Matadero Creek can be made. This diversion of flow allows for full one-percent flood protection along Barron Creek. Backwater analyses for Matadero Creek with an upstream reduction in flow and the design diversions from Barron Creek indicate that the Stanford Storage Alternative is not, by itself, adequate to provide one-percent flood protection between San Francisco Bay and Ross Road. The selection of an additional conceptual remediation alternative would be required for this reach of Matadero Creek.

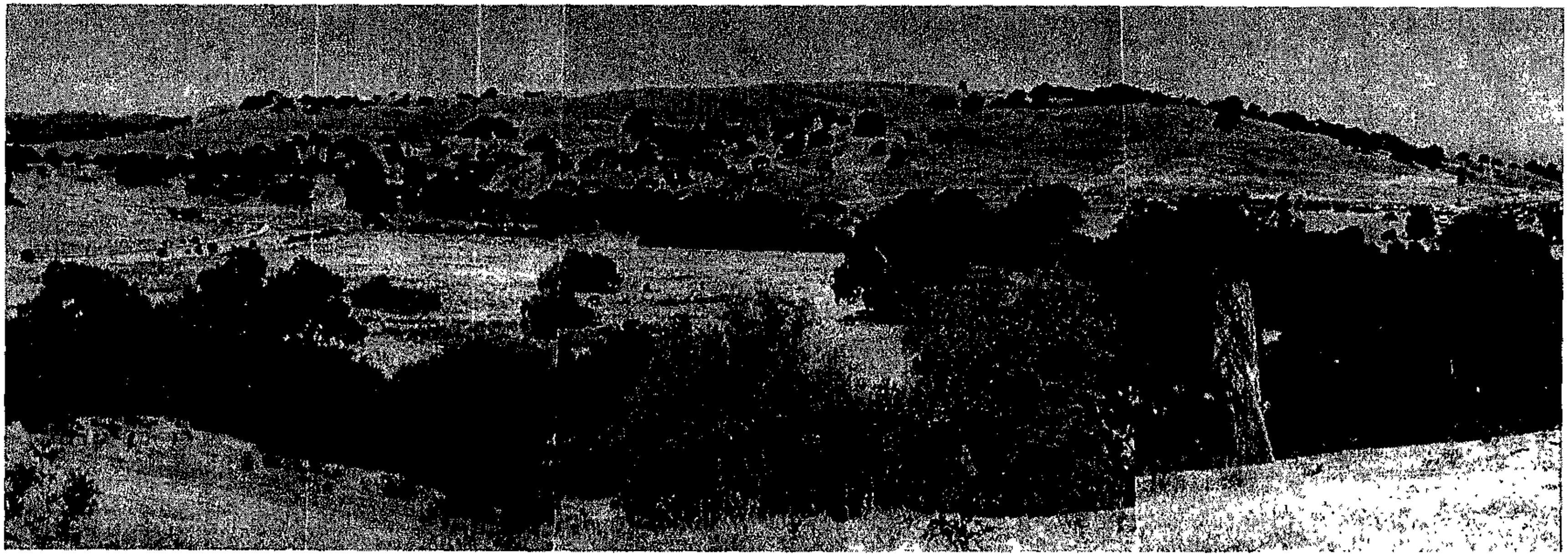

Photo 5-1. Potential Off-Stream Storage Pond Site at Page Mill Road and Foothill Expressway

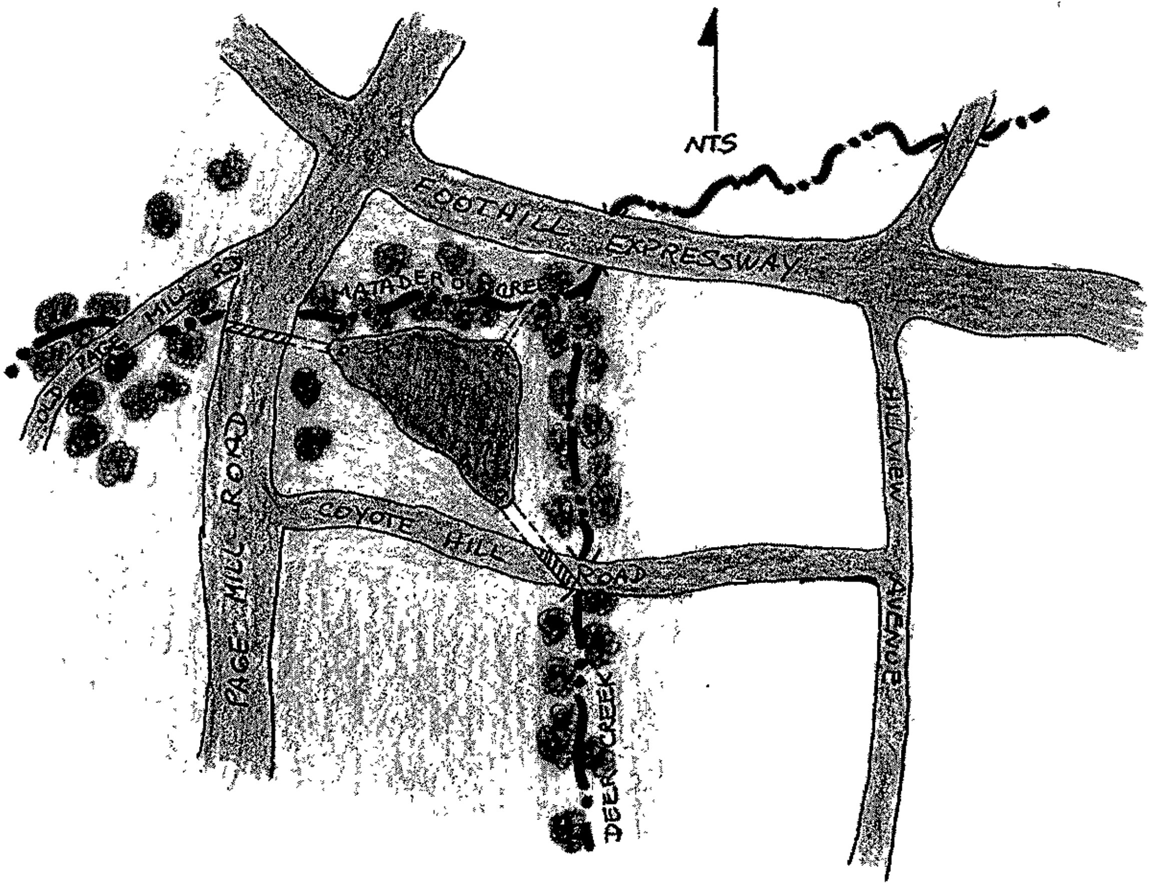

Figure 5-3. Schematic of 130 acre-foot Off-Stream Storage Basin

Environmental Impacts. Most of the potential detention site is located away from the riparian corridor and used as pasture for horses. This land use would not necessarily be affected by this project alternative. Construction of overflow spillways from Deer Creek and Matadero Creeks, and the necessary drainage facilities shown in Figure 5-3 could potentially impact riparian habitat and red-legged frog populations. Although detailed biological assessments of construction impacts associated with an upstream storage facility have not been made for this planning study, Stanford biologists have been evaluating this site for on-campus mitigation, and suggest that this location provides red-legged frog habitat.

However, sufficient grazed areas are available immediately adjacent to the riparian corridor to provide on-site mitigation for riparian impacts adjacent to Coyote Hill Road or Page Mill Road. In essence, the width of the riparian corridor could be increased, while reducing the impact of the grazing on creek bank erosion and pollutants — sediment and fecal matter — entering the stream.

Project Costs. Land costs for upstream site acquisition are assumed to be $1 million per acre, based on a survey of nearby land sales in Palo Alto (Appendix E). Leasing the necessary land to construct and operate the 130 acre-foot detention facility is estimated to cost $25 million with contingencies. Construction and mitigation costs for the off stream storage facility are estimated to be $5 million, so storage basin costs total $30 million. The cost of additional remediation still necessary in the downstream reaches of Matadero Creek is $10 million. Therefore, the total cost of this alternative would be approximately $40 million, which is at the limit of feasibility.

Alternative Feasibility

The Stanford Storage Alternative is considered infeasible and impractical because the facility does not detain enough flood volume to significantly reduce the scope of downstream remediation. In addition, construction of the storage facility would reduce the availability of areas suitable to mitigate for riparian habitat impacts caused by necessary remediation downstream of Highway 101. Implementing this alternative also reduces the potential of future mitigation credits for Stanford on this site, and may impact red-legged frog habitat. Finally, the cost of this alternative is high.

RENZEL MARSH ALTERNATIVE

To provide backwater relief at Highway 101, flood flows in excess of existing downstream channel capacity could be allowed to overflow through a spillway cut into Matadero Creek's northern levee into Renzel Marsh. This would expand the flood basin during high flow periods by providing additional off-stream storage within the marsh. Figure 5-4 shows the location of the Renzel Marsh, which the City of Palo Alto created in the 1980s to demonstrate the benefits of using tertiary treated wastewater for marsh habitat creation. Many members of the community with an interest in this bayland environment have expressed support for this area to remain undisturbed.

Description of Alternative

Under this alternative, flood flows in excess of approximately the five-year return period would be allowed to pass through a 200-foot wide spillway created in Matadero Creek's northern levee just downstream from East Bayshore Road. To provide sufficient backwater relief at Highway 101, the crest of the spillway would be set at an elevation of 3.5 feet NGVD'29. A levee system tying back to higher ground would prevent an increase in flood risk to properties adjacent to East Embarcadero Road. Ring levees around the ITT communications facility are also required. A new pump station would dewater the storage area after spill events, limiting marsh inundation to two weeks duration.

Alternative Screening

Fundamental evaluation criteria described in Chapter 4 have been used to test the Renzel Marsh Alternative for feasibility:

Flood Protection. During the one-percent flood event, water would spill into the marsh area. Estimated one-percent spills to the marsh total 850 acre-feet. If the marsh is empty prior to the runoff event, predicted water levels in the marsh could reach an elevation of 4.4 feet NGVD'29, which is one foot higher than the lowest elevations on the northern side of the marsh at East Embarcadero Road. Containment levees are needed around the marsh to protect adjacent areas of Palo Alto. The one-percent water surface elevation at Highway 101 is maintained at an approximate elevation of 5.6 feet NGVD'29, which is consistent with assumed one-percent flood conditions in the 1988 Engineer's Report.

The Renzel Marsh Alternative solves the problem of a constricted channel between the Palo Alto Flood Basin and Highway 101, although floodwall improvements are still required for adequate freeboard.

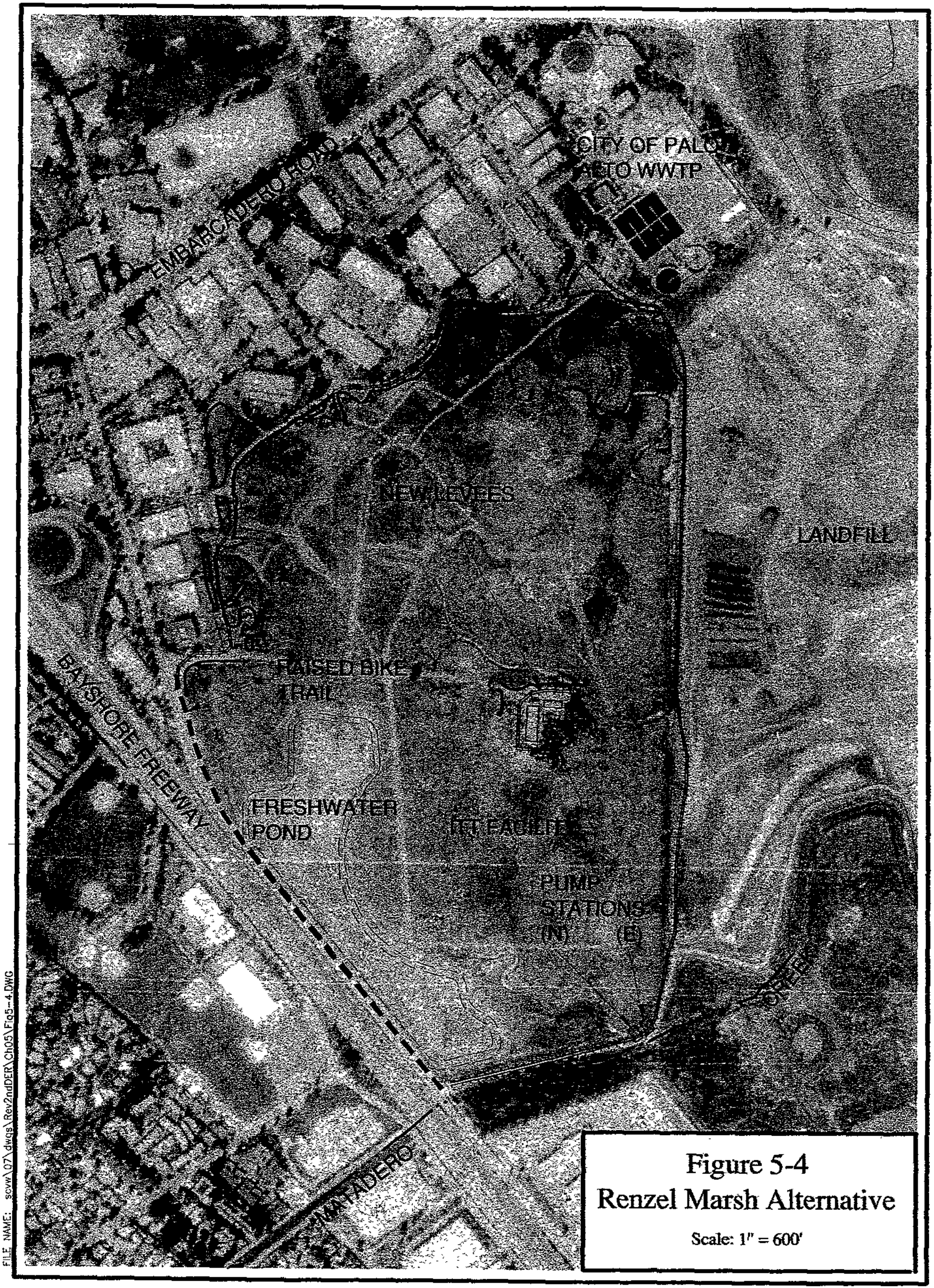

Figure 5-4
Renzel Marsh Alternative
Scale: 1" = 600'

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Environmental and Ecological Impacts. This alternative has a direct environmental impact due to the construction of containment levees, and an indirect impact on ecology by altering the hydrology of the Renzel Marsh environment. Both impacts require mitigation. Approximately 8,500 lineal feet of containment levee would have to be built around the marsh. The containment system would be between 1 to 4 feet above adjacent grade. Visual impacts resulting from this project element would be significant and unavoidable, and mitigated with landscaping and aesthetic design elements.

The footprint of the proposed levee containment system that is located outside of the East Bayshore Road pedestrian/bike path is within USACE jurisdictional wetlands. Along East Bayshore Road for a distance of 2,300 feet, containment can be provided by elevating the existing paved bicycle/pedestrian path by three to four feet. This action requires an encroachment into wetland habitat of 0.53 acre. In other locations the levee can either be situated in wetland habitat or upland areas where ordinance-sized trees would be lost. By avoiding an alignment that requires the loss of a number of large trees, the estimated impact to jurisdictional wetlands is 1.42 acres. For the purpose of estimating wetland mitigation costs, the biologists' opinions are that habitat mitigation will be at a 2:1 ratio (2.84 acres), with similar saltwater marsh habitat located as near to the impact site as possible. To create this habitat, salt evaporation ponds in the South Bay would be converted to saltwater marsh subject to tidal action.

Ring levees necessary to protect the ITT site total 2,200 lineal feet, and would be at an average height of seven feet above adjacent grade, with a twenty-foot top width and sides slopes compacted at 2:1 (horizontal to vertical). The footprint of this containment levee impacts 12.0 acres of saltwater marsh. This impact would be mitigated by acquiring 24 acres of salt evaporation ponds and converting them to saltwater marsh habitat.

Approximately 0.05 acre of riparian habitat would be impacted by constructing the overflow spillway on the Matadero Creek bank. This impact would be mitigated at a 3:1 ratio, using suitable areas identified in Chapter 6. Based on those identified riparian mitigation sites, the 0.15 acre of riparian mitigation could be accomplished within District rights-of-way.

Saltwater habitat would be inundated by freshwater spills from Matadero Creek every five years on average. The operation of this facility would increase the frequency, depth and duration of flooding within the Emily Renzel Marsh, and constitutes an indirect environmental impact.

Breeding populations of California clapper rail are found in nearby marshes. They are potential visitors to the marsh and may use it as occasional foraging habitat and as a refuge when nearby tidal marshes are inundated during high tides and flood events. Intermittent flooding up to nine feet in depth would be sufficient to further reduce or eliminate upland refuges. The anticipated duration of marsh inundation during a one-percent flood event is two weeks. This has the potential to increase the clapper rails' exposure to predation. Late winter storm runoff events that spill water to the marsh could cause the loss of a breeding season's production within the marsh and adjacent levee slopes for a number of bird species. Since there is a twenty percent annual chance of overflow to the marsh, this is considered to be a significant impact.

Increased depths of marsh flooding during extreme runoff events would be sufficient to substantially reduce or eliminate any populations of salt marsh harvest mice within the marsh. This marsh likely hosts a population of this species, so this impact is significant. The impact may reduce genetic variability within the surviving population, and make the survivors less able to withstand future challenges.

It is the opinion of mammalogists and ornithologists that the nesting habitat impacted by the increased frequency of freshwater flooding, albeit rare, in the saltwater habitat due to this conceptual alternative can be mitigated at a ratio of 1:1 (H.T. Harvey and Associates, 2001.) This will create permanent habitat for animal populations and replace the habitat periodically impacted by flood events. The areal extent of periodic inundation is estimated to be about 243 acres. Mitigation would be provided by converting South Bay salt evaporators into saltwater marsh habitat.

This conceptual alternative has been presented to City of Palo Alto staff, Emily Renzel, and others in the environmental community. Many members of the community have expressed opposition to this alternative due to its adverse impacts on the saltwater habitat of the marsh.

Project Costs. Table 5-2 summarizes estimated construction and mitigation costs for the Renzel Marsh Alternative, assuming that adequate salt evaporation ponds can be acquired for wetland mitigation. Total estimated project cost is $47 million, for which detailed cost estimates are provided in Appendix E. The Renzel Marsh Alternative exceeds the limit of feasible project cost. Most of the estimated cost is for the conversion of salt ponds into saltwater habitat to mitigate project impacts.

Table 5-2
Estimated Costs for Renzel Marsh Alternative

Project Element	*Estimated Cost*
Construction	$5,000,000
Mitigation Work	$27,000,000
Land Acquisition for Mitigation	$6,000,000
Contingencies	$9,000,000
TOTAL COST	**$47,000,000**

Alternative Feasibility

The Renzel Marsh Alternative is considered infeasible and impracticable because of high cost and significant impact to 240 acres of saltwater marsh habitat.

FLOW DIVERSION ALTERNATIVES

Conceptual diversion alternatives are considered to reduce the design discharge conveyed within certain reaches of Matadero and Barron Creeks, and eliminate the need for channel remediation. Creek discharges can be reduced by diverting a percentage of the one-percent flood discharge around inadequate portions of the system.

Two basic flow diversion alternatives have been considered:

1) A complete bypass of Matadero Creek between the PAFB and Alma Street; and

2) A downstream bypass of Matadero Creek between the PAFB and Highway 101.

The Complete Bypass Alternative would provide full remediation for one-percent riverine flooding on Matadero and Barron Creeks. For the Downstream Bypass Alternative, additional remediation above Highway 101 is required. Figure 5-5 shows each concept.

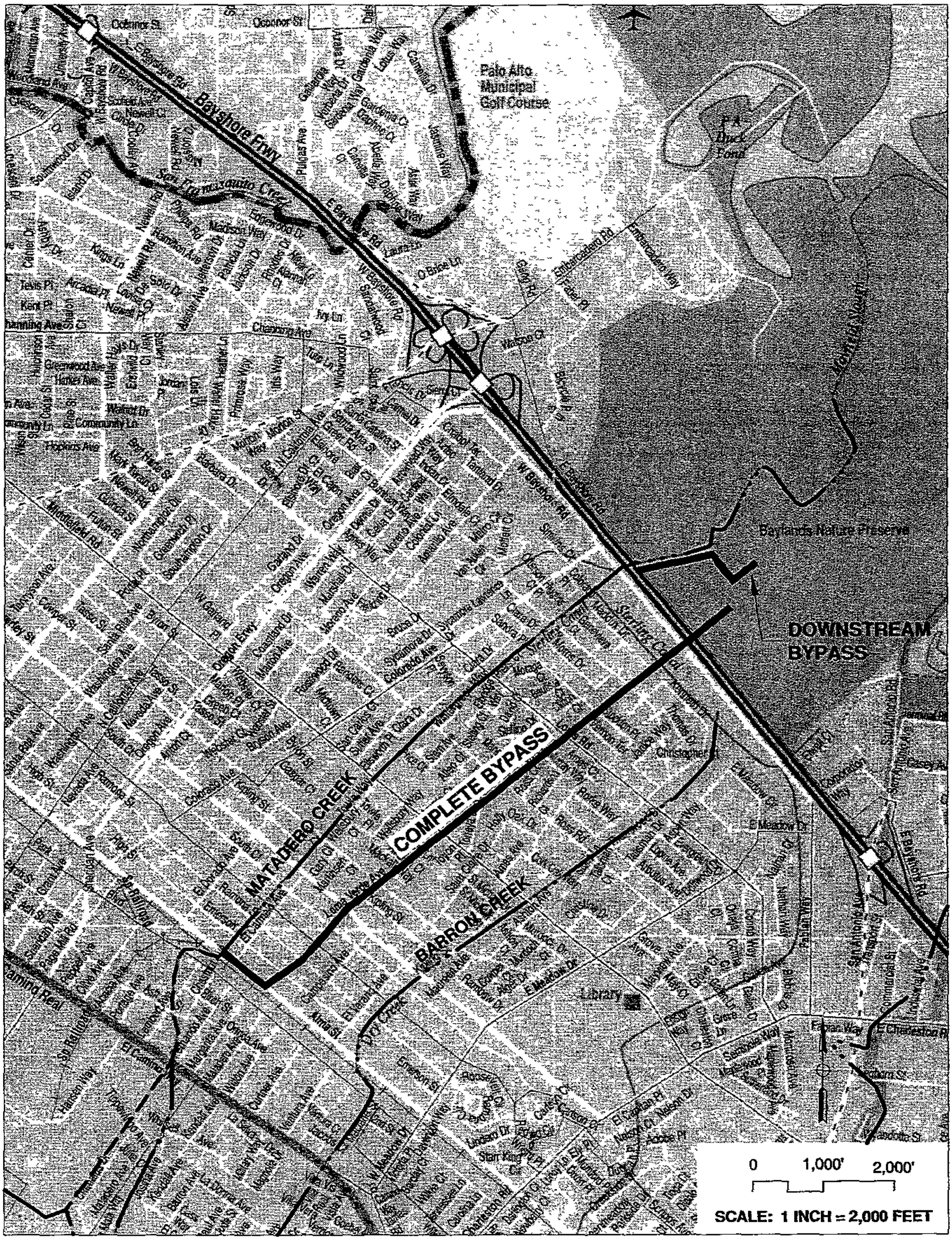

Figure 5-5. Flow Diversion Alternatives

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COMPLETE BYPASS ALTERNATIVE

To eliminate the need for channel improvements to the Matadero Creek channel, if full diversions from Barron Creek are implemented, Matadero Creek flows must be reduced by 1,100 cfs at Alma Street. Lesser rates of flow diversion have not been investigated because substantial downstream channel improvements would still be required.

Description of Alternative

Figure 5-5 shows the conceptual alignment of a proposed 20-foot by 8-foot underground box culvert that could safely convey 1,100 cfs under the Southern Pacific Railroad, past the identified problem areas of Matadero Creek, and into the Palo Alto Flood Basin. The total length of the diversion structure would be approximately 10,000 feet. The structure would consist of a cast-in-place reinforced concrete box with manholes for ventilation and access every 500 feet. To avoid the purchase of private rights-of-way, the proposed route is within city streets. While the structure can be accommodated within residential street right-of-way, it is anticipated that this project alternative would require the relocation of a significant number of private and public utilities.

Alternative Screening

Using the screening criteria from Chapter 4, the Complete Bypass Alternative has been evaluated for feasibility.

Flood Protection. The complete bypass alternative allows Matadero Creek to carry the reduced one-percent discharge, and the maximum design one-percent diversion from Barron Creek, within the existing creek channel below the natural ground elevation. Freeboard improvements would not be necessary, and both Matadero Creek and Barron Creek would be afforded protection against one-percent riverine flooding.

Environmental Impacts. Constructing an underground diversion along Loma Verde Avenue from Alma Street to the Palo Alto Flood Basin would have significant short-term impacts to residential neighborhoods and traffic circulation during construction. Relocating utilities to accommodate the diversion structure's footprint would be very disruptive to the community, time consuming and expensive. Some minor environmental impact to wetland habitat at the PAFB outfall would be mitigated at a 2:1 ratio, requiring the conversion of 0.02-acre of upland area on District right-of-way bordering the northeast side of the Municipal Services Center to freshwater marsh.

Project Costs. The total cost of shoring and excavation, dewatering, bypass construction, utility relocation, traffic control, and street restoration is estimated to be $75 million. A construction cost estimate is included in Appendix E.

Alternative Feasibility

The Complete Bypass Alternative is considered infeasible and impracticable because of its $75 million capital cost, and community impact during construction.

DOWNSTREAM BYPASS ALTERNATIVE

For this alternative, bypass construction is limited to the reach downstream of Highway 101. This eliminates the need to cross the Southern Pacific Railroad or Caltrans right-of-way, but project remediation is *still* required upstream of Highway 101.

Description of Alternative

Figure 5-5 shows a conceptual alignment for a bypass facility that would carry about one-half of the one-percent discharge from Highway 101 into the Palo Alto Flood Basin. Depending upon the route, the total length of the downstream diversion structure would be about 1,500 feet. The downstream bypass would consist either of an open channel or of an underground structure with open channel flow. The downstream bypass would be constructed within District or City of Palo Alto right-of-way. An underground bypass would require the relocation of a significant number of private and public utilities.

Alternative Screening

Using the screening criteria from Chapter 4, the Downstream Bypass Alternative has been evaluated for feasibility:

Flood Protection. The Downstream Bypass Alternative allows the existing Matadero Creek channel downstream of Highway 101 to convey a reduced one-percent discharge, so that the design water surface elevation at Highway 101 is less than 6.0 feet NGVD'29, and is consistent with the water surface assumed in the 1988 Engineer's Report. Spills to the MSC at the peak of Matadero Creek's discharge would be eliminated, and remediation upstream of Highway 101 is better facilitated with a lower starting water surface elevation.

Environmental Impacts. Constructing an underground bypass limits environmental impact to 0.4 acre of habitat, while an open channel bypass would impact 0.9 acre of habitat.

Project Costs. The total cost of shoring and excavation, dewatering, bypass construction, utility relocation, traffic control, and street restoration are estimated to be on the order of $8 million for an open channel bypass and $15 million for an underground bypass. Construction cost estimates are included in Chapter 6 and Appendix E.

Alternative Feasibility

The Downstream Bypass Alternative is feasible since it achieves project objectives downstream of Highway 101, and the unavoidable impacts to riparian vegetation and wetland can be adequately mitigated, as more fully discussed in Chapter 6.

CHANNEL MODIFICATION ALTERNATIVES

Channel modification alternatives would improve the ability of the combined Matadero and Barron Creek systems to deliver the one-percent flood discharge so that adequate freeboard is provided, freshwater flood risks are reduced, and the burden of mandatory flood insurance purchases is limited to the one-percent tide flood hazard zone. This would meet the basic project objectives outlined in 1988 and restated at many public forums. Channel modifications to both Barron Creek and Matadero Creek have been screened for feasibility.

BARRON CREEK MODIFICATION ALTERNATIVE

One conceptual alternative is to modify Barron Creek so that its base flood discharge could be contained without requiring diversions to Matadero Creek.

Description of Alternative

Preliminary hydraulic analyses for Barron Creek improvements necessary for the channel to contain its entire one-percent flood discharge of 740 cfs have been made. Photos 2-16 and 2-17 show the limitations of the District's right-of-way along Barron Creek between Ramona Street and El Camino Real. Without condemning additional right-of-way, the conceptual approach to increasing channel capacity is to:

1) Raise floodwalls between Louis Road and El Camino Real;

2) Replace inadequate bridges; and

3) Increase the capacity of the culvert between El Camino Real and Laguna Avenue, either with a larger diameter pipe, or with a parallel pipe.

Preliminary hydraulic analyses indicate that once these improvements are made, the height of required floodwalls to contain the increased discharge between Ramona Street and El Camino Real are on the order of 15 feet as measured from natural ground.

Alternative Screening

The fundamental screening criteria for alternative feasibility have been applied to the Barron Creek Modification Alternative:

Flood Protection. This alternative would provide protection against the one-percent flood on Barron Creek without the need for upstream diversions to Matadero Creek. However, as discussed previously for upstream storage and diversion alternatives, reducing Barron Creek diversions to zero does not provide adequate freeboard on Matadero Creek.

Environmental Impacts. The 15-foot high floodwalls required in some reaches of Barron Creek for this alternative would be a negative aesthetic impact that cannot be adequately mitigated and is clearly unacceptable based on alternative floodwall heights presented at public meetings.

Project Cost. Appendix E provides an estimated cost for this conceptual alternative of approximately $20 million. About $10 million in downstream Matadero Creek improvements would still be necessary to provide one-percent flood protection. The total project cost of this alternative is therefore about $30 million.

Alternative Feasibility

This conceptual alternative is considered infeasible and impracticable because floodwalls up to 15 feet in height would be required on Barron Creek, and significant improvements are still required to provide one-percent flood protection on Matadero Creek.

MATADERO CREEK CHANNEL MODIFICATIONS

Three alternatives are available to improve Matadero Creek conveyance and meet project objectives:

1) raise channel floodwalls;

2) enlarge the channel; and

3) replace bridges.

RAISE FLOODWALLS ALTERNATIVE

For this conceptual alternative, Matadero Creek floodwalls would be raised to meet NFIP and District standards for freeboard without any other channel or bridge modification. To provide one-percent flood protection along Barron Creek, full diversion would be allowed to Matadero Creek.

Description of Alternative

Floodwalls and bridge headwalls would be added, raised or replaced in order to provide freeboard meeting FEMA and District standards. Downstream of Highway 101, existing maintenance practices would continue and sediment would continue to accumulate in the channel overbank until quasi-equilibrium is reached at MHHW. A new floodwall along the MSC would prevent spills to the south, and a new floodwall or higher levee between Matadero Creek and Renzel Marsh would mitigate the increased risk of flooding to the north. Table 5-3 summarizes the necessary floodwall elevations for this alternative.

Table 5-3
Floodwall Elevations for "Raise Floodwalls" Alternative

Location	*Natural Ground (ft NGVD'29)*	*WSEL (ft NGVD'29)*	*Existing Floodwall (ft NGVD'29)*	*Required Floodwall (ft NGVD'29)*	*Floodwall Height (feet)*
W Bayshore Rd	6.0	9.21	9.0	13.21	7.2
Greer Rd	7.0	10.79	10.0	14.79	7.8
Louis Rd	8.0	14.80	11.2	18.80	10.8
Ross Rd	11.0	16.95	13.3	20.95	10.0
Middlefield Rd	15.3	18.80	17.3	22.80	7.5
Cowper St	18.5	20.85	19.8	24.85	6.4
Waverley St	19.0	23.18	20.0	27.18	8.2
Bryant St	22.8	23.10	23.5	27.10	4.3
SPRR	26.0	27.12	29.0	31.12	5.1
Park Blvd	28.0	29.51	29.5	33.51	5.5
Lambert Ave	30.0	30.12	31.5	34.12	4.1
El Camino Real	31.5	31.07	32.5	N/A	1.0

Alternative Screening

The fundamental screening criteria for alternative feasibility have been applied to the Raise Floodwalls Alternative for Matadero Creek:

Flood Protection. This alternative would provide protection against the one-percent flood on Barron Creek and Matadero Creek.

Environmental Impacts. For safety and aesthetic considerations, a six-foot high floodwall (as measured from lowest adjacent grade) is considered to be the general limit of feasibility. This limit has been established based on community input during public meetings. Between Highway 101 and Waverley Street, requisite floodwall heights are in excess of the limit of feasibility. Downstream of Highway 101, floodwall alignments would be placed to avoid impacts to riparian habitat.

Project Cost. Based on an extrapolation of floodwall improvement cost estimates given in Appendix E, this alternative is estimated to cost $15 million. Due to the increase in bridge headwall heights, it is assumed that half of the bridges between Louis Road and Lambert Avenue would need to be replaced because of the potential uplift pressure.

Alternative Feasibility

This conceptual alternative is not feasible without conjunctive remediation improvements, due to the necessity of floodwalls over 10 feet in height on Matadero Creek. Raising floodwalls is, however, considered to be a feasible alternative if the resulting wall heights are not excessive.

CHANNEL ENLARGEMENT ALTERNATIVE

For this conceptual alternative, the cross sectional area of the Matadero Creek channel would be enlarged to better convey the one-percent design discharge with full diversion from Barron Creek. Floodwalls would be modified only as necessary to provide adequate freeboard.

Description of Alternative

Downstream of Highway 101, the creek channel would either be restored to its 1971 surveyed cross section, or other channel modifications would be made that restore the channel conveyance assumed in the 1988 Engineer's Report. A maintenance plan for annual sediment management would be included with project remediation. Portions of the concrete-lined flood protection channel between Highway 101 and Alma Street would be enlarged from the current trapezoidal configuration to match the rectangular "U-frame" section upstream of the Southern Pacific Railroad.

Alternative Screening

Fundamental screening criteria for alternative feasibility have been applied to the Channel Enlargement Alternative for Matadero Creek:

Flood Protection. This alternative would provide protection against the one-percent flood on Barron Creek and Matadero Creek.

Environmental Impacts. Adverse environmental impacts are concentrated in the reach downstream of Highway 101. The channel excavation necessary to increase conveyance would result in the loss of up to 4 acres of a high quality riparian corridor along the southern overbank area of Matadero Creek below East Bayshore Road. This riparian corridor provides a rich habitat for a variety of species due to dense vegetation, a well-defined understory, and proximity to San Francisco Bay. Between Highway 101 and Ross Road, an increase in floodwall heights relative to existing conditions would be mitigated with aesthetic wall treatments.

Project Cost. Enlarging Matadero Creek from the Palo Alto Flood Basin to Alma Street is estimated to cost up to about $38 million, which is within the limit of project feasibility. Other feasible permutations of floodwall, bridge and channel modifications are available to reduce estimated project costs, as explained in Chapter 6.

Alternative Feasibility

This conceptual alternative is feasible because it provides one-percent flood protection within the study area, its environmental impacts are of a magnitude that can be reasonably mitigated, and its cost is within the limits of feasibility.

BRIDGE REPLACEMENT ALTERNATIVE

By itself, this conceptual alternative cannot remedy identified flood protection problems. However, replacing selected bridges could help reduce the scope of necessary floodwall and/or channel enlargement improvements upstream of Highway 101.

Description of Alternative

As explained in Appendix H, backwater effects could be lessened by increasing the area of bridge openings, and correspondingly reducing energy losses through bridges. Table 5-4 provides a summary of surveyed areas for each bridge opening between West Bayshore Road and Alma Street. The survey was made after sediment was removed from the channel in Spring 1999.

Table 5-4
Comparison of Matadero Creek Bridge Openings

Bridge Location	Measured Net Area (square feet)	Δ WSEL Across Bridge[1] (feet)
West Bayshore Road	750	0.1
Greer Road	360	0.9
Louis Road	200	3.9
Ross Road	230	2.0
Middlefield Road	240	1.5
Cowper Street	200	1.4
Waverley Street	230	1.4
Bryant Street	260	0.1
Alma Street / SPRR	190	3.2

[1] Changes in water surface elevations due to each bridge are from analysis of the 1% flood using existing channel conditions without allowing wall overtopping.

Based on the bridge head losses presented in Table 5-4, the Louis Road and Ross Road bridges are the most likely candidates for modification, as is the Alma Street / Railroad culvert. However, by improving the downstream culvert-to-channel transition at Alma Street, the change in water surface elevation across the railroad culvert does not compromise one-percent flood protection.

Bridge modifications could include either raising the bridge or removing it altogether. Based on field surveys, raising Louis Road by one foot at Matadero Creek is feasible; raising the Ross Road bridge is not feasible, due to sight distance limitations. Removing certain roadway crossings from traffic and replacing bridges with pedestrian / bicycle bridges has also been explored. City of Palo Alto engineering staff have indicated that the adverse impact on traffic cannot be adequately mitigated. The removal of Louis Road, which would have the greatest hydraulic impact, would eliminate a busy thoroughfare with a bike path and bus route. Some members of the public with direct access to Louis Road have expressed support for this option (traffic volumes on Louis Road would almost certainly diminish), while those living on neighboring streets have expressed opposition, since traffic volumes on other streets would likely increase.

Alternative Screening

Since this alternative is intended to supplement other remediation projects, only the latter two screening criteria for alternative feasibility have been applied:

Environmental Impacts. Temporary road closures and traffic detours would be necessary during the replacement of the Louis Road bridge, which is expected to last up to six months. Vehicular and pedestrian traffic would likely be routed to Greer Road and Ross Road via Loma Verde Avenue and Colorado Avenue. Once the bridge is reopened, however, vehicular and pedestrian traffic should return to existing patterns.

Eliminating the use of the Matadero Creek crossing for all but pedestrians and bicycles at Louis Road would significantly alter traffic patterns in this residential neighborhood. Although traffic and emergency access to all property can be maintained, the elimination of through traffic on Louis Road between Loma Verde and Colorado would inevitably increase traffic flow on Greer Road and Ross Road between the two cross streets. For these reasons, the City of Palo Alto has indicated that eliminating vehicular traffic on Louis Road at Matadero Creek is not acceptable.

Potential project impacts to local storm drainage and driveway access would be mitigated as described more fully in Chapter 6.

Project Cost. Replacing the Louis Road bridge at a higher elevation is estimated to cost about $1 million including structural bridge replacement, roadway modifications, local drainage improvements, traffic control, and contingencies.

Alternative Feasibility

This conceptual alternative is feasible because it provides increased flow conveyance at a reasonable cost with minimal environmental impact. The replacement of the Louis Road bridge as a project element in combination with other floodwall and channel enlargement alternatives is considered further in Chapter 6.

SUMMARY

Evaluations of the conceptual alternatives described in this chapter are summarized in Table 5-5. Using the screening process presented in this chapter, twelve conceptual alternatives have been categorized as feasible or not feasible as summarized below. Chapter 6 presents the evaluation of feasible project alternatives.

FEASIBLE ALTERNATIVES

Downstream Flow Bypass

Raise Matadero Creek Floodwalls

Matadero Creek Channel Enlargement

Louis Road Bridge Replacement

INFEASIBLE ALTERNATIVES

No Project

Non-Structural Approaches

Upstream Reservoir

Stanford Pasture Storage

Renzel Marsh Storage

Complete Flow Bypass

Barron Creek Modification

Table 5-5
Matadero/Barron Creeks Remediation - Summary of Conceptual Alternatives

Problems, Concerns and Impacts	Existing Conditions	No Project	Non-Structural Approaches	Upstream Reservoir Construction	Off-Stream Storage on Stanford Land	Off-Stream Storage At Renzel Marsh
Description of Conceptual Alternatives	Major problem is lack of adequate capacity to carry one-percent design flow. Other significant problems include sedimentation and local drainage.	No measures taken to reduce risk of flooding. Existing condition would remain, if not worsen.	Flood damage to structures would be solved without channel modification. About 3,500 structures would be floodproofed. Regulating floodplain development would not apply, since floodplain is fairly well developed. Existing condition would remain.	Construct reservoir parallel to Page Mill Road above Foothill Expressway. This would require relocating Page Mill Road and Junipero Serra Highway (280).	Build off-stream storage pond at Foothill Expressway and Page Mill Road on Stanford lands.	Cut a 200-ft. wide spillway into Matadero Creek's northern levee downstream of Highway 101 to allow flood flows in excess of existing channel capacity to overflow into Renzel Marsh.
Flooding Problems	Annual risk of flooding is greater than one percent; additional mandatory flood insurance will be required.	Existing condition would remain. Expected annual flood damages are estimated to be $2 million.	Flooding would still occur, causing some damages, disruption of services and resulting in cleanup costs.	A 600 acre-foot reservoir would solve downstream flooding problems	Off-stream storage pond alone would not eliminate need for mandatory flood insurance. Additional channel modifications would be necessary to provide one-percent protection to non-tidal areas.	Eliminates channel conveyance capacity limitations between 101 and PAFB. Would require new containment levees around Renzel Marsh
Equal Level of Flood Protection	No	No	No	Yes	Not without additional channel work on Matadero Creek downstream of Ross Rd.	Not without additional remediation work on Matadero Creek upstream of Highway 101
Environmental Impacts	N/A	N/A	N/A	Loss of 5 acres of riparian corridor; geomorphological impacts due to impoundment of streamflow;	Storage pond would inundate what is now pasture land, but what may be red-legged frog habitat	Periodic inundation would cover 240+ acres of marsh, disrupting Clapper Rail and Salt Marsh Harvest Mouse habitats
Estimated Project Cost as 2001 Present Worth	N/A	$5 million for continued mandatory flood insurance	$250 million to flood-proof 3,500 structures	$80 million estimated project cost	$40 million estimated project cost	$47 million estimated project cost
Summary	N/A	Not feasible because it does not provide one- percent flood protection along both creeks.	Not feasible due to high cost. Residual damages from flooding would continue	Not feasible because of high cost and environmental impacts	Not feasible or practical due to cost and need for additional downstream remediation. Reduces potential mitigation area.	Not feasible due to significant environmental impacts

Table 5-5
Matadero/Barron Creeks Remediation - Summary of Conceptual Alternatives (continued)

Problems, Concerns and Impacts	Complete Bypass of Matadero Creek	Bypass of Matadero Creek Downstream of 101	Barron Creek Modification	Raise Matadero Creek Floodwalls Only	Matadero Channel Enlargement	Matadero Creek Bridge Replacement
Description of Conceptual Alternatives	Construct box culvert from Southern Pacific Railroad to convey flows underground through Palo Alto directly to the Palo Alto Flood Basin (PAFB).	Either an open channel or underground bypass would be construction downstream of Highway 101 to expand flood flow capacity in that reach	Raise floodwalls from Louis Rd. to El Camino Real; replace inadequate bridges; increase culvert capacity between El Camino Real and Laguna Ave.	Levees, floodwalls and bridge headwalls from PAFB to Lambert Ave. would be added, raised or replaced	Matadero Creek downstream of Highway 101 would be enlarged to restore flood flow capacity; a "U-frame" channel would replace trapezoidal channel in sections between Highway 101 and Alma St.	Replacement of selected bridges that cross Matadero creek
Flooding Problems	Box culvert would divert adequate flow to provide one-percent protection on both Matadero and Barron existing channels, except in areas subject to tidal flooding.	Bypass would convey about one-half of the one percent flow and provide one-percent protection to City's Municipal Services Center	These modifications would provide one-percent flood protection on Barron Creek with no diversion to Matadero Creek necessary	Adequate freeboard would be provided to meet FEMA and District standards with floodwall/levee modifications	These modifications would provide one percent flood protection for both Matadero and Barron Creeks	These modifications could help reduce the scope of necessary floodwall and/or channel enlargement improvements upstream of Highway 101
Equal Level of Flood Protection	Yes	Not without additional channel work on Matadero Creek upstream of 101	No. Adequate freeboard not provided on Matadero Creek	Yes	Yes	Not without additional channel/floodwall improvements
Environmental Impacts	Construction impacts and minor loss of wetland habitat at PAFB outfall	Between 0.5 and 2.5 acres of riparian/wetland habitat would be impacted.	Floodwalls along Barron Creek would be as high as 15 feet above existing ground.	Floodwalls along Matadero Creek would be as high as 10 feet above existing ground.	About 4 acres of riparian/wetland habitat would be impacted	Temporary construction impacts; significant traffic impacts if a bridge is removed
Estimated Project Cost as 2001 Present Worth	$75 million estimated project costs	$8 million for overflow bypass; $15 million for underground bypass	$30 million for Barron Creek and Matadero Creek improvements	$15 million estimated project cost	$38 million estimated project cost	$1 million to replace Louis Road Bridge
Summary	Not feasible due to high cost	Feasible project costs and environmental impacts that can be mitigated	Not feasible due to unequal protection and excessive floodwall heights.	Not feasible because of excessive floodwall heights	Feasible because it provides equal level of flood protection and environmental impacts can be reasonably mitigated	Bridge replacement is feasible because it provides increased flow conveyance at reasonable cost and minimal environmental impact; bridge removal is not feasible due to traffic impacts.

CHAPTER 6
FEASIBLE ALTERNATIVES

INTRODUCTION

Conceptual alternatives identified as feasible in Chapter 5 are evaluated in a more refined manner in this chapter. Using evaluation criteria detailed in Chapter 4, feasible alternatives are compared so a feasible alternative that meets project objectives in a cost-effective manner can be recommended. Project objectives outlined in Chapter 2 are reiterated below:

1) Provide a level of flood protection along Matadero and Barron Creeks consistent with District policies and the policies of the Federal Emergency Management Agency (FEMA) as administered through the National Flood Insurance Program (NIP).
2) Reduce the burden of mandatory flood insurance for properties adjacent to Matadero and Barron Creeks upstream of Alma Street / Central Expressway.
3) Reduce the risk of riverine flooding on Matadero and Barron Creeks throughout the study area, providing equivalent levels of flood protection insofar as this is practicable.
4) Maintain District facilities to ensure that they continue to provide the level of flood protection for which they were constructed, both to protect the public's investment and to comply with regulations of the federal flood insurance program.
5) Provide mitigation for any significant and unavoidable environmental impacts.

When formulating a project, the District attempts to define solutions requiring the minimum amount of environmental impact and cost to achieve the identified objective. Chapter 5 has identified feasible alternative solutions that meet project objectives with a reasonable cost and environmental impact. Final plan selection is a balance between often conflicting objectives. As such, a reasonable increase in project cost (for one project alternative relative to another) may be justified if one particular plan has significantly less adverse impacts and strong public support.

Feasible alternatives for Matadero Creek channel modifications are discussed on a reach-by-reach basis in the remainder of this chapter, with more rigorous evaluations relative to Chapter 5. Alternatives are evaluated on the basis of environmental impact, cost, future maintenance, and ancillary issues such as local drainage.

ENGINEERING CRITERIA

Appendix F details the hydrologic analyses that were performed to estimate design one-percent flowrates relevant to Matadero Creek channel modifications. Starting water surface elevations for backwater analyses are provided by Appendix G, which also discusses Palo Alto Flood Basin operation. Appendix H presents channel hydraulic analyses methodologies, including roughness values and bridge modeling. Freeboard and other design criteria are discussed in Chapter 2.

AVAILABLE SITES FOR ENVIRONMENTAL MITIGATION

One of the stated project objectives is to mitigate significant and unavoidable environmental impacts resulting from the project. Adequate mitigation is primarily a function of how much land is available, either on- or off-site, to meet mitigation requirements established by the US Army Corps of Engineers, California Department of Fish and Game, and other state and federal agencies with jurisdiction. The relative ease or difficulty of providing mitigation for a feasible project alternative will be a factor in the project selection process.

A reconnaissance of the Matadero and Barron Creek watersheds, as well as watersheds adjacent to the study area has been made to identify potential mitigation areas and provide an evaluation of suitability in order of ranking. Specific on-site mitigation opportunities for individual project alternatives are discussed throughout this chapter. Off-site mitigation areas, together with site ownership and associated constraints, are briefly discussed below. For more detail regarding the feasibility of mitigation sites, and a jurisdictional delineation of these sites, readers are referred to the project EIR. Potential off-site mitigation areas are shown on Figure 6-1.

International School

A promising location for riparian mitigation is on San Francisquito Creek at Laura Lane, on the bay side of Highway 101 directly across from the main Palo Alto Post Office (off-site location "A" on Figure 6-1). Two acres of in-kind riparian mitigation may be developed at the site, which is owned by the District. Although the property is separated from San Francisquito Creek by a District access road, a portion of the parcel could be planted so that it would eventually become contiguous with the canopy of the existing creekside vegetation. Additional mitigation opportunities exist along the opposite (north) bank of San Francisquito Creek at this site. Unvegetated slopes along the creek could be planted to create a dense riparian habitat where none currently exists. The most positive aspect of this site is that it is already owned by the District. A large portion of the site, which has been leased to a landscaping contractor, would be repossessed. The site is not located within the Matadero Creek watershed.

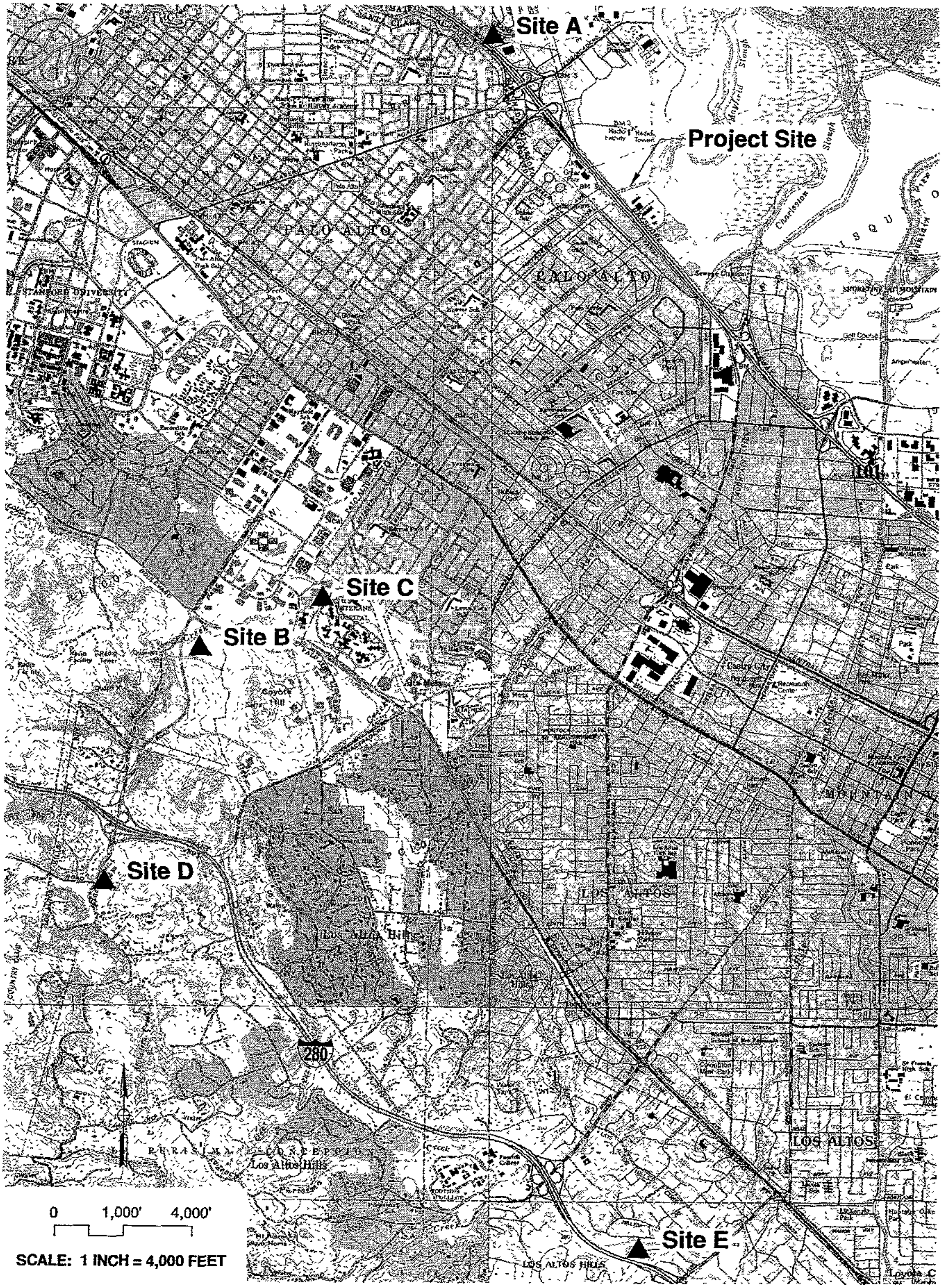

Figure 6-1. Potential Mitigation Site Vicinity Map

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Stanford Pasture

Within the Matadero Creek watershed, there is an opportunity to improve the riparian corridors that exist along Matadero and Deer Creeks at their confluence near Foothill Expressway. (Photo 5-1 and Figure 6-1 show this area, which is labeled as off-site location B.) Based on a field delineation by H.T. Harvey & Associates, about six acres could be planted with riparian vegetation adjacent to high quality riparian habitat. These potential mitigation sites are located on Stanford University land. Stanford officials have expressed reluctance to lease land that could be used as mitigation for their own projects, or would provide a jurisdictional delineation that would preclude future development on the site. This site is considered to be feasible for riparian mitigation, although it is distant from the area of project impact.

Veterans Administration Hospital

The third choice for off-site mitigation is upstream on Matadero Creek along the rear of the Veterans Administration Hospital (off-site location C on Figure 6-1). The riparian corridor in this area consists of a very narrow strip of mature native trees. Immediately adjacent to the creek is approximately one acre of a gravel lot presently used for temporary parking and storage. The removal of existing surface material (gravels and fill) and replacement with appropriate soils, followed by the planting of these areas, would greatly enhance this stretch of Matadero Creek and provide a greater buffer from the anthropogenic disturbances associated with the hospital's activities. This mitigation site is also desirable in that it allows for mitigation along the same creek that is being impacted. Negative aspects include federal ownership of the site and its distance from impacted areas.

District-Owned Parcels

District staff have investigated other potential mitigation sites on land currently owned ~~in~~ fee or in easement, within the Matadero Creek, Barron Creek, San Francisquito Creek, Adobe Creek, Hale Creek, Permanente Creek, and Stevens Creek watersheds. Two potential mitigation sites have been identified during a field assessment of each District-owned property conducted by H.T. Harvey and Associates.

Arastradero Road. Approximately 0.2 acre of suitable riparian mitigation could be created on this site, which is on Matadero Creek and owned by the District (off-site location D on Figure 6-1). The site is distant from the location of project impact, and is relatively small in area.

Hale Creek. This site, which is leased to an outside party, is owned by the District (off-site location E on Figure 6-1). Although the site is located outside of the Matadero Creek watershed, it abuts high quality riparian habitat, and about one acre of additional habitat could be created with riparian plantings.

Table 6-1 lists the five sites, totaling 11 acres, that have been identified as feasible for off-site riparian mitigation. The ranking provided in this table reflects the biologists' assessment of the sites' potential to create habitat that most closely replicates the area of direct project impact. (H.T. Harvey, 2001) Wetland habitat will be created within project limits for those feasible alternatives requiring wetland mitigation.

Table 6-1
Summary of Potential Off-Site Riparian Mitigation Areas

Site	*Location*	*Acreage*	*Rank*	*Ownership*	*Possible Constraints*
A	International School	2.0	1	District	out of watershed
B	Stanford Pasture	6.0	2	Stanford	distance from site
C	Veterans Hospital	1.0	3	Veterans Admin.	distance from site
D	Arastradero Road	0.4	4	District	distance from site
E	Hale Creek	1.0	5	District	out of watershed
	TOTAL POTENTIAL	11.0			

DELINEATION OF PROJECT REACHES

Remedial work on Matadero Creek has been categorized into two distinct project reaches based on the degree of conveyance improvement required:

- The reach between the Palo Alto Flood Basin (PAFB) and Highway 101 requires substantial improvement for flow conveyance.
- The reach from Highway 101 to Alma Street requires improvements to channel conveyance and/or elevated floodwalls, to provide adequate freeboard.

REACH 1 - PALO ALTO FLOOD BASIN TO HIGHWAY 101

Sediment accumulation and the establishment of riparian vegetation in Matadero Creek between the PAFB and Highway 101 have reduced channel conveyance and substantially increased the risk of flooding to properties between the freeway and Ross Road. Restoring conveyance for large flood flows is required in this reach in order to reduce backwater effects upstream of Highway 101.

The objective in this reach is to reduce one-percent backwater at Highway 101 from the "no project" condition, which is 7.4 feet NGVD'29, to less than 6 feet NGVD'29, thereby restoring the downstream conveyance assumed in the 1988 Engineer's Report. Two conceptual alternatives, a downstream bypass to provide overflow relief, and channel enlargement to increase capacity, are identified as feasible in Chapter 5. These two concepts have been expanded to four feasible remedial alternatives in this reach for detailed analysis and discussion:

Overflow Bypass — Construct an overflow bypass downstream of Highway 101.

Underground Bypass — Construct an underground flow bypass downstream of Highway 101.

Channel Restoration — Restore this channel reach to its 1971 condition by enlarging the existing channel section.

Expanded Floodway — Modify the channel by removing a portion of the silt and vegetation, thereby restoring flood flow capacity to equivalent 1971 levels.

Overflow Bypass Alternative

To avoid the most serious impacts to mature riparian habitat adjacent to the existing Matadero Creek channel associated with channel modifications in the creek, flood flows would be partially diverted through a high flow bypass constructed parallel to Matadero Creek and just to the north of the MSC boundary. This bypass would avoid the most valuable habitat area along the creek.

Project Description. The overflow bypass would occupy the 15- to 20-foot wide bank area along the MSC fence line, which is comprised primarily of a grove of non-native Eucalyptus trees and a gravel-topped levee, and some riparian habitat areas. The bypass alignment is shown on Figure 6-2.

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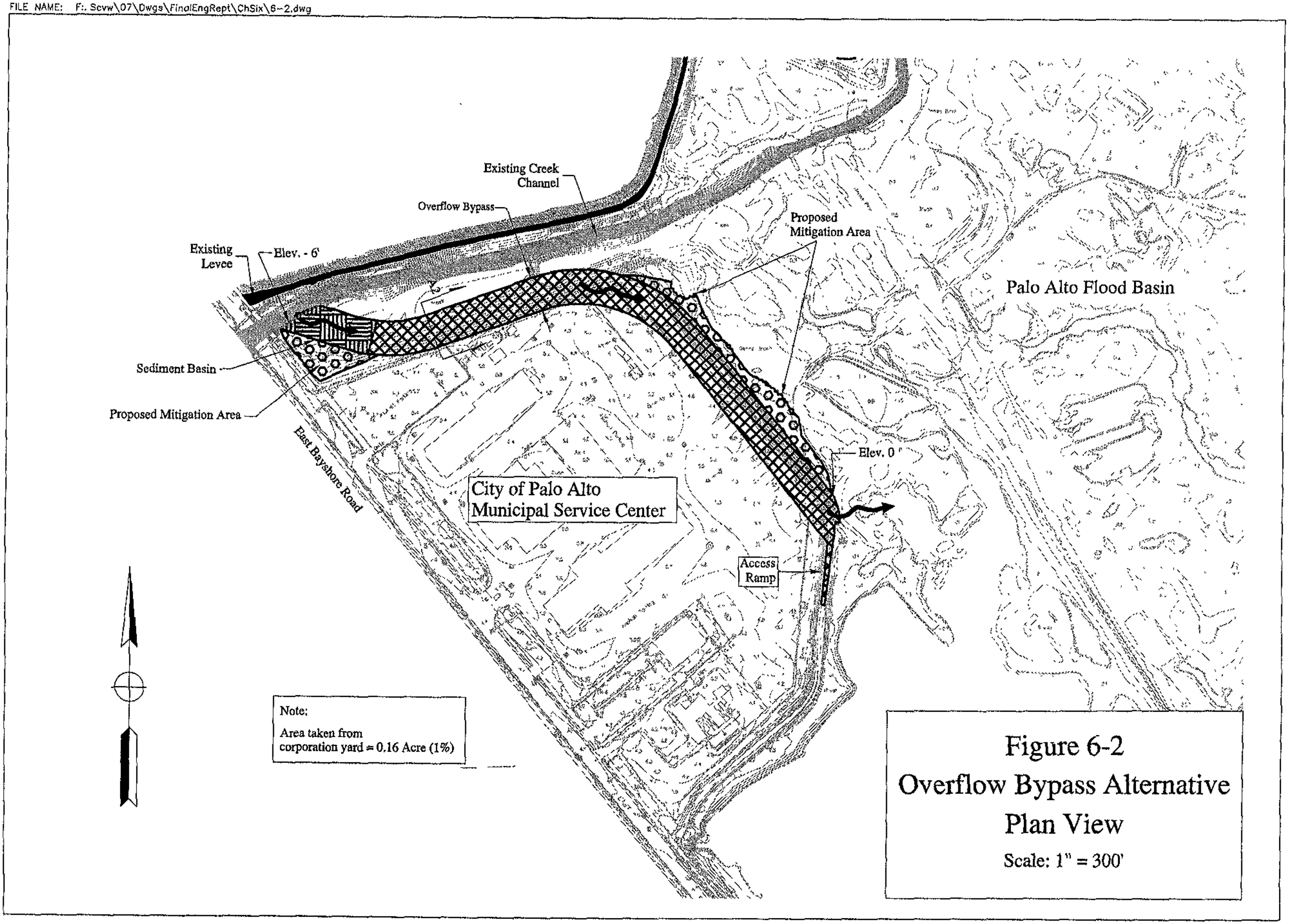

Note:

Area taken from
corporation yard = 0.16 Acre (1%)

Figure 6-2
Overflow Bypass Alternative
Plan View
Scale: 1" = 300'

The bypass would follow a curved turn at the northern-most corner of the MSC (requiring the purchase of roughly 0.2 acre of property), continue to the southeast along the MSC's northeastern property line, cross the existing levee, and discharge into the PAFB. It is proposed that the leveed area between the new bypass and PAFB be used for on-site riparian and wetland mitigation. The ground in this area would be leveled to an elevation of 0 ft. to -1 ft, and planted with appropriate riparian and wetland vegetation to blend with the existing stands of willow and other native plants.

To contain the two-year maintenance flow in the original creek channel, the proposed sediment basin access ramp would slope upward from an elevation of -6.0 feet NGVD'29 at the bridge exit to elevation +2.0 feet NGVD'29 at the bypass entrance near the MSC. Maintenance vehicles would access the sediment basin ramp along the bypass, which would continue toward the flood basin with a bottom elevation of -1.0 feet NGVD'29. The bypass invert would be approximately 1.5 feet above the flood basin's normal pool elevation to prevent standing water from remaining in the bypass over long periods of time.

Since the protective levee around the MSC would have to be partially removed to construct the bypass, a levee or vertical wall would be built around the MSC at elevation 8 feet NGVD'29. This elevation provides a level of flood protection compatible with other reaches of Matadero Creek, which is one of the project objectives. Relevant discussions of flood protection adjacent to the PAFB and upstream creek reaches are provided in Appendix G and Appendix I, respectively.

Hydraulic Performance. Overflow bypass conveyance capacity is evaluated by comparing the downstream backwater at Bayshore for various bypass options, and assuming that overbank areas silt up to Mean Higher High Water (elevation 4.3 feet NGVD'29), while the low-flow channel shape is self-maintaining, as demonstrated over the past thirty years. Under the one-percent flood condition, the main channel would convey about one-half of the 3,100 cfs base flood discharge and the bypass would convey the remainder. At the peak of Matadero Creek's one-percent discharge hydrograph, the backwater elevation at the downstream face of East Bayshore Road would be 5.7 feet NGVD'29.

Constructing an overflow bypass is expected to result in less sediment deposition within the creek overbanks in the long term, and should also provide some local drainage relief in the areas just upstream from Highway 101.

Environmental and Ecological Impacts A majority of the mature riparian vegetation along the main creek channel would remain undisturbed, but some mitigation would still be required for habitat loss near the MSC. Necessary floodwalls along the MSC boundary could limit views of the creek channel and riparian habitat from the MSC, but would not be considered a significant visual/aesthetic impact. During construction, contaminated soil may be encountered from fuel storage facilities located on the northern portion of the MSC. The extent of the encounter will depend upon the exact bypass alignment selected. Construction disturbances include noise and dust generation, and temporary construction staging on the MSC property.

The ruderal and eucalyptus-dominated habitat along the northern boundary of the MSC is used by several wildlife species, but is of much lower value to wildlife than adjacent riparian and wetland vegetation. Project construction would need to be monitored to minimize impacts to the San Francisco garter snake (if present), birds such as cliff swallows nesting under Highway 101, and waterfowl breeding and nesting activities.

Figure 6-3 shows jurisdictional habitat areas that could be impacted by proposed project construction, which assumes an 80-foot wide footprint of direct impact as measured into District right-of-way from the boundary with the MSC. The most environmentally sensitive bypass cross section is one that minimizes the width of its footprint, even if a more "structural" cross section is necessary to achieve this.

Alternative Bypass Sections. "Softer" approaches to bypass construction utilizing an earthen bank and bottom rather than a more durable materials have been investigated, as shown in Figure 6-4. This option would require the most habitat removal and mitigation, but it has the benefit of the most natural appearance. Based on geotechnical recommendations, banks would be sloped at 3:1 (horizontal to vertical) and would be planted with grassy vegetation. Flood protection to the MSC would be provided by an 18-foot wide driveable levee. This width is required to allow equipment access for periodic sediment and vegetation removal on the channel bottom, since it will be difficult to operate sediment removal equipment on the soft floor.

The major drawback to this option is that the width of jurisdictional channel area adjacent to the MSC used to create the bypass increases by 25 feet, so the total impact to riparian habitat is nearly three acres. This impact would likely have to be mitigated with 9 acres of riparian habitat. A second drawback is the likelihood that riparian vegetation would become established fairly quickly along the invert and lower bank area of the bypass, requiring increased maintenance efforts.

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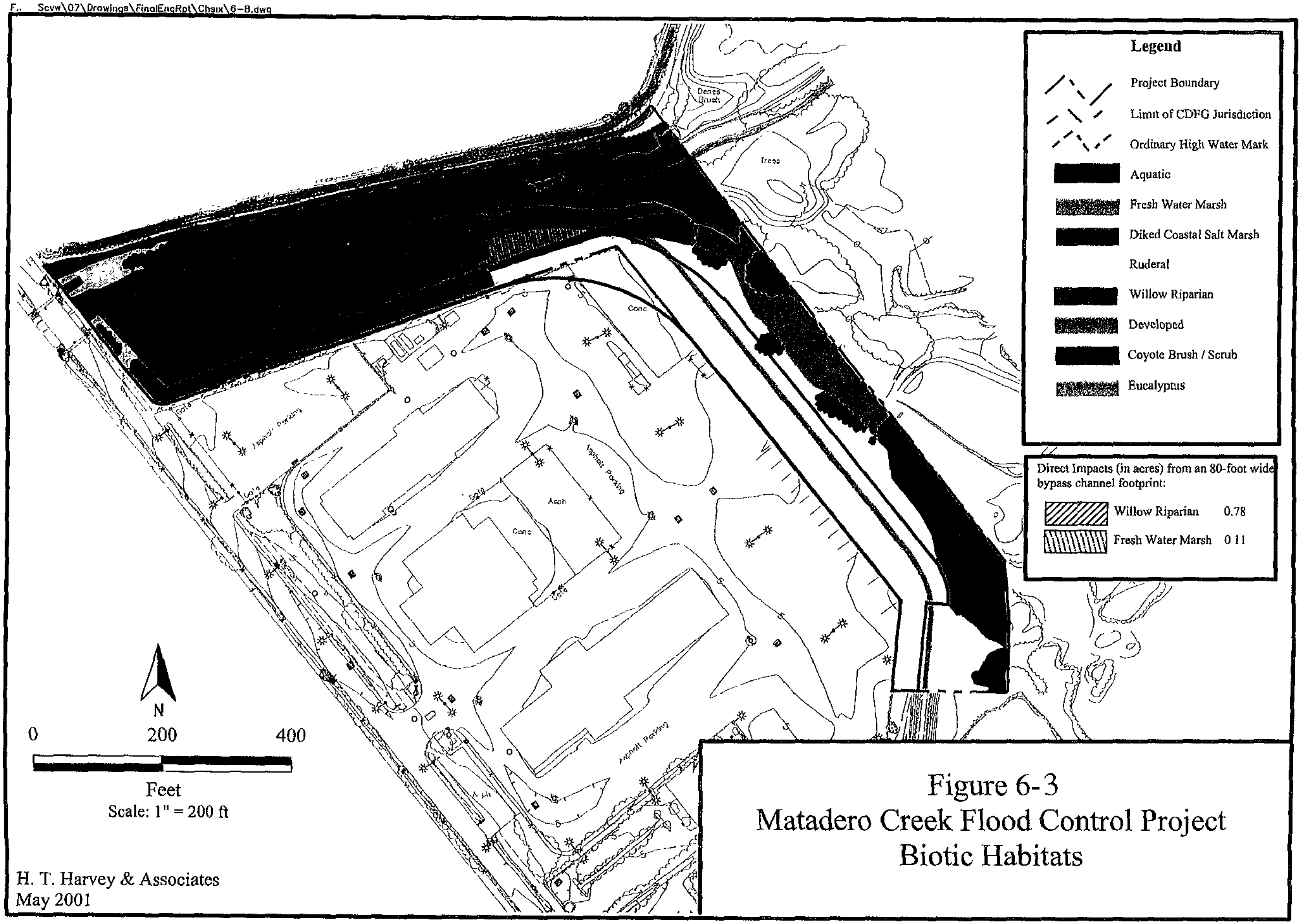

Figure 6-3
Matadero Creek Flood Control Project
Biotic Habitats

H. T. Harvey & Associates
May 2001

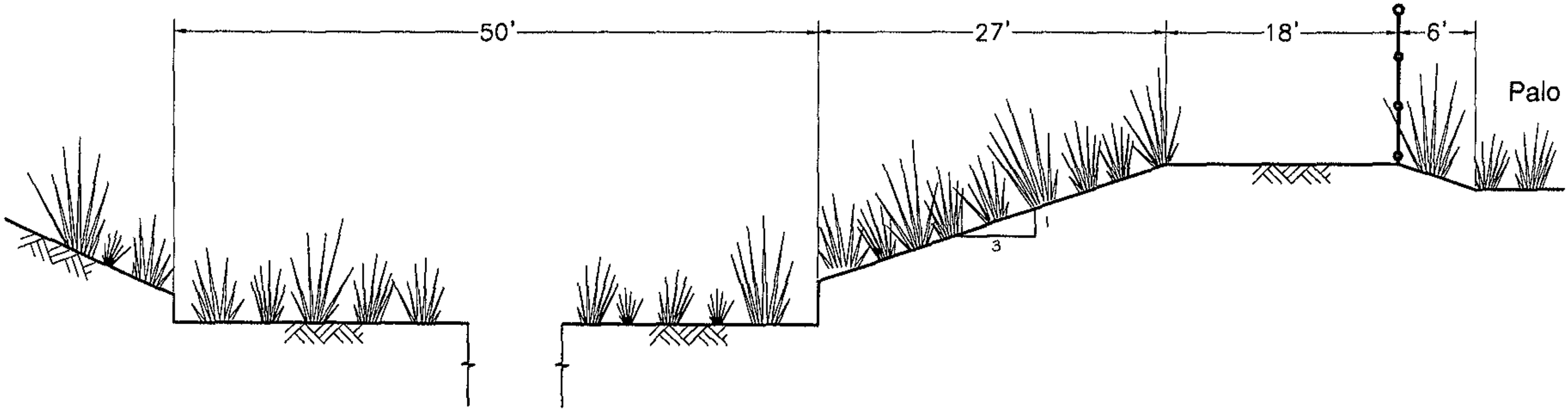

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Figure 6-4
Overflow Bypass Alternative
with Earthen Embankment

Proposed Section. A biotechnical solution that improves the appearance of the bypass without sacrificing high quality habitat is proposed (Figure 6-5). This option relies upon a gravity retaining wall system of interlocking concrete blocks or web cells such as Earthstone™, Keystone®, Geoweb® or other commercially available product. Pockets within the wall system may be planted with vegetation, and the concrete blocks or web cells themselves can be ordered in various colors and textures. Typical gravity retaining walls can be constructed at an angle of 20° to 30° from the vertical. To provide a durable floor for periodic maintenance, a poured concrete slab is essential for the bypass bottom to allow for the passage of maintenance equipment, and sediment removal activities. Periodic removal of sediments and established vegetation would have to be conducted so that riparian vegetation would not encroach into the defined bypass area. Vegetation appropriate for use within the retaining wall would be established on the banks. Figure 6-6 shows the cross section in context with the existing riparian corridor.

Table 6-2 lists environmental impacts and mitigation for this reach alternative, which requires an 80-foot wide section for a 60-foot bypass and ten feet on each side for construction buffers, as shown in Figure 6-3. On-site mitigation opportunities are available for both riparian and marsh habitat creation. In contrast to the expanded floodway alternative, this alternative allows for a net increase of riparian habitat associated with Matadero Creek.

Table 6-2
Impacts and Mitigation for Overflow Bypass Alternative

		Mitigation		
Habitat	*Impact (ac)*	*On-Site (ac)*	*Off-Site (ac)*	*Total (ac)*
Willow Riparian	0.78	0.97	1.37	2.34
Freshwater Marsh	0.11	0.22	0.00	0.22
TOTAL	0.89	1.19	1.37	2.56

The estimated mitigation in Table 6-2 can be met on District-owned land to adequately mitigate project impacts. The highest ranked mitigation site, Site A — International School, is proposed as off-site mitigation for this project alternative.

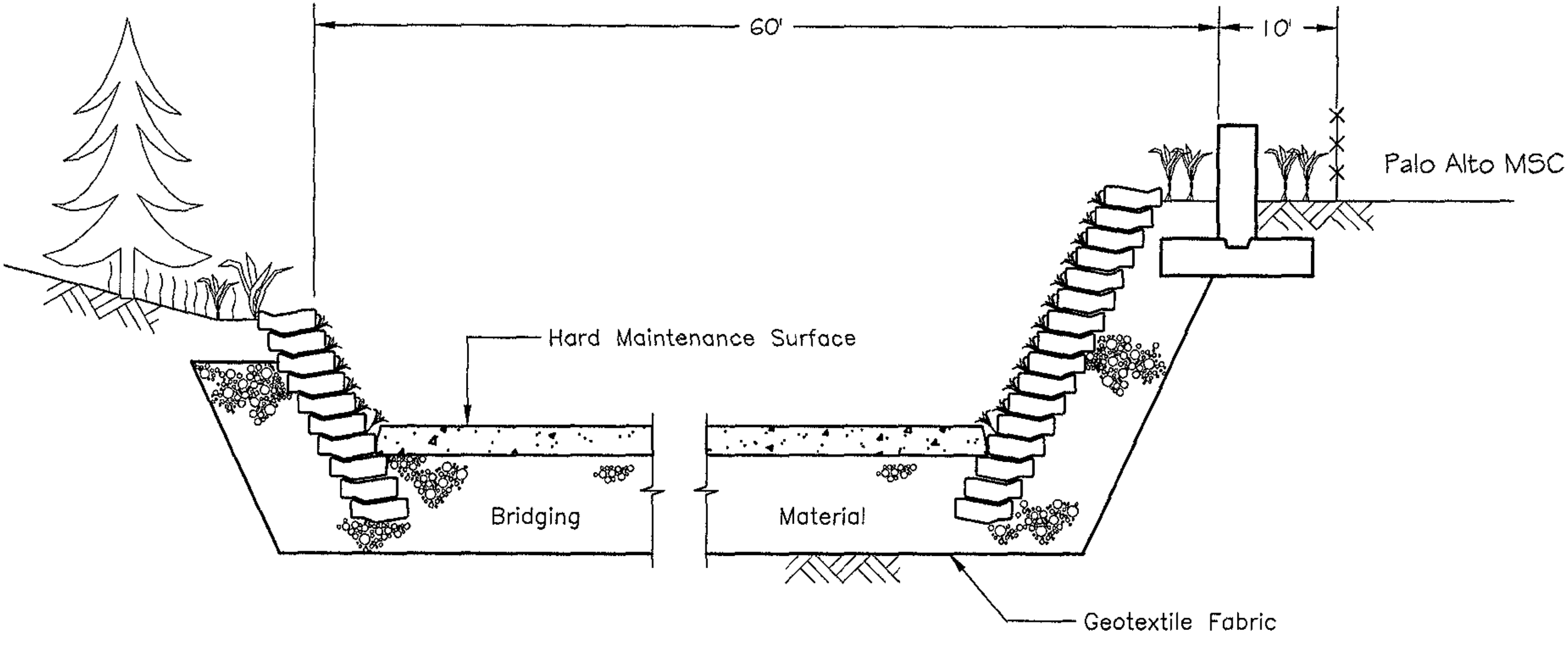

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Figure 6-5
Overflow Bypass Alternative
with Gravity Retaining Wall

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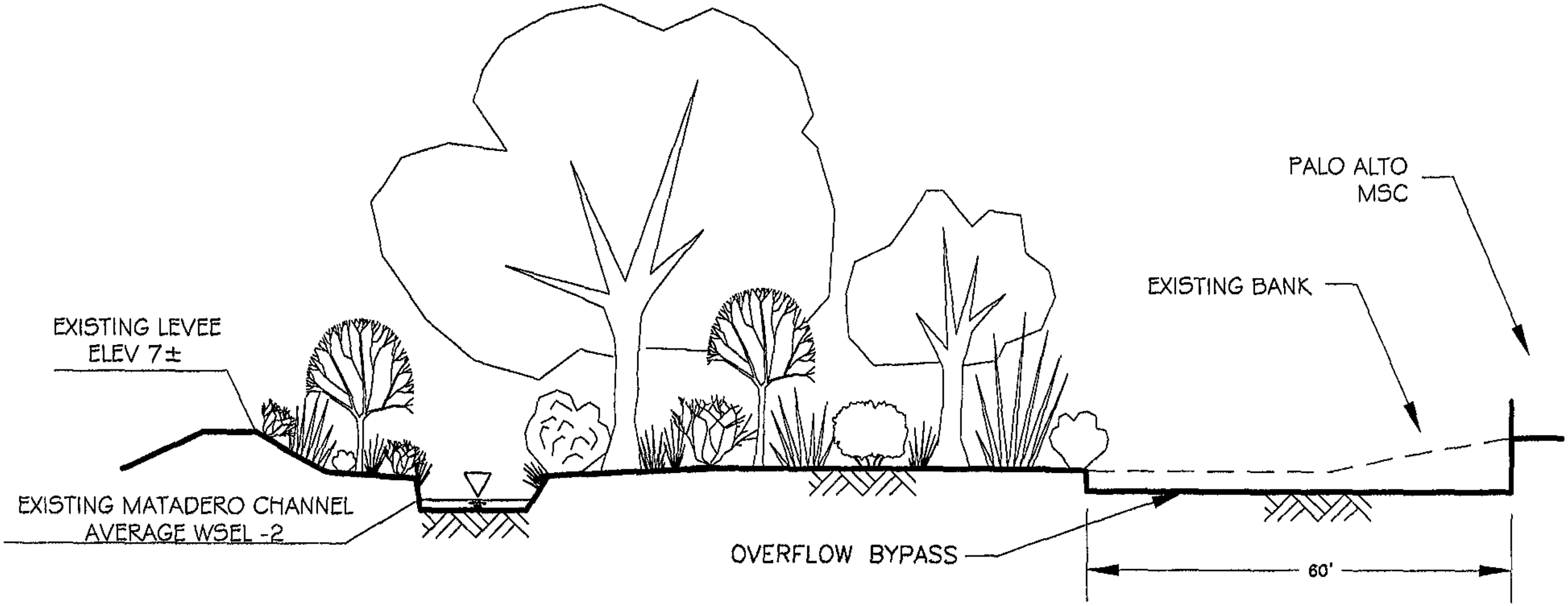

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Figure 6-6
Overflow Bypass Alternative
Cross-Sectional View

Geotechnical Impacts. Material that would be removed during bypass excavation contains organics, would be very saturated, and should be hauled to a suitable disposable area. Construction dewatering will be necessary during excavation. The existing subgrade is anticipated to consist of soft and saturated clay materials. Bridging materials would be required within the dewatered excavation to support construction traffic. The bypass bottom would be supported on the bridging material.

Hazardous Materials Impacts. Soil and groundwater sampling at the fuel storage tank area, fueling area, and transformer storage area at the MSC has confirmed the presence of petroleum hydrocarbons along the bypass alignment. (Lowney, 2001) Since soil excavation and dewatering activities would occur adjacent to the MSC boundaries during construction of the bypass, soil and groundwater contamination would have to be remediated. Soil and groundwater containing petroleum hydrocarbons may be encountered within approximately 75 feet of the MSC storage tank area. During construction contaminated soil and water will need to be handled as described in Chapter 7.

Structural Engineering Considerations. Construction of a bypass with near-vertical walls would require installing sheet piling or drilled-in-place soldier piles (to minimize vibration, disturbance, and noise) adjacent to the MSC fence line to retain the sides of the 5- to 7-foot deep excavations. The use of interlocking sheet piles or some other barrier to groundwater flow is recommended to reduce the quantity of contaminated groundwater requiring disposal. Drain rock or bridging material overlaying a geotextile stabilization fabric and weepholes (to drain granular backfill behind the wall) would be required to reduce excessive hydrostatic pressure against the wall system. The concrete slab would be placed over the bridging material with walls cantilevered from the poured invert slab. Retaining walls would be backfilled with permeable material. Shoring systems could either be removal after backfilling operations, or left in place.

Right-of-Way Considerations. Construction of the concrete bypass channel and the maintenance access ramp along the boundary of the MSC would occur primarily within the easement granted to the District by the City of Palo Alto in 1967 for flood control purposes. Temporary construction easements may need to be obtained from the City of Palo Alto to allow for construction staging and vehicular access. This alternative requires that the District acquire 0.16 acre of MSC property on its northeastern corner.

Further acquisition of City right-of-way could reduce environmental impacts by shifting the bypass alignment further outside of jurisdictional habitat. Moving the bypass channel closer into the MSC and its paved parking area would therefore reduce mitigation requirements. The City has conducted a feasibility study/needs assessment for the Municipal Services Center to identify options for future expansion, replacement, or relocation of the facility. The study considered the potential operational impacts, including loss of storage and parking areas, and reduced emergency response capability, of the District's proposed encroachment into the existing facility footprint. Based on discussion and negotiation with City staff, the bypass alignment presented in this report represents a compromise solution for both parties, although the final alignment and appurtenant details remain to be designed by the District and approved by Palo Alto.

Maintenance. A quiescent pool of water with a hard maintenance floor would be created at the bifurcation point between the existing creek channel and the entrance to the high-flow bypass to capture some of the sediment bedload downstream of East Bayshore Road. Approximately 3,000 cubic yards of sediment could be allowed to accumulate within the overflow bypass without compromising hydraulic performance, as measured by the water surface at Highway 101. This amount of sediment deposition would need to be removed every four years on average, assuming that recent sediment deposition history is repeated. Maintenance access provisions for this project alternative allow for the regular removal of accumulated sediments within the bypass and beneath the freeway bridges using typical tracked equipment.

Estimated Costs. Table 6-3 summarizes estimated project costs for the overflow bypass alternative, as detailed in Appendix E. The present worth of annual maintenance costs for this alternative is about $500,000.

Table 6-3
Estimated Costs for Overflow Bypass Alternative

Project Element	*Estimated Cost*
Construction	$5,750,000
Mitigation Work	$490,000
Land Acquisition for Construction	$160,000
Contingencies	$1,600,000
TOTAL COST	**$8,000,000**

Underground Bypass Alternative

This alternative is considered to minimize intrusion into the Matadero Creek channel downstream of Highway 101 and the riparian vegetation along its banks. Figure 6-7 presents a plan for this alternative, which would entail a 40-foot wide, 8-foot high box culvert constructed under East Bayshore Road to divert high creek discharges around the existing Matadero Creek channel.

Project Description. The proposed underground bypass for this alternative would utilize a multi-cell concrete box culvert, constructed underneath East Bayshore Road, which would daylight to the Palo Alto Flood Basin just south of the Animal Services Center. A sediment basin would be excavated just downstream of the pedestrian/bicycle bridge to trap sediment and help minimize sediment accumulation in the box culvert itself. Higher flood flows in Matadero Creek would be diverted to the box culvert via an inlet structure located near Matadero Creek just downstream of Highway 101. Some habitat loss would occur at the location of the sediment basin, and Figure 6-7 depicts the mitigation area.

The proposed box culvert would be 8 feet high to allow mechanized access for clearing sediment and debris. This height would also prevent the culvert flow from pressurizing during peak bypass flows, which could result in excessive head loss and compromise the culvert's conveyance capacity. The culvert would span the entire roadway of East Bayshore, requiring significant utility relocation efforts and elevating the roadway to at least 6 feet (NGVD'29). Building this underground bypass would also require modifications to the main entrance road to the MSC, which is presently at an elevation of 3.5 feet (NGVD'29), and to other driveways along the alignment to provide reasonable vehicular access. Figure 6-8 provides a cross section for the proposed underground bypass.

Hydraulic Performance. This culvert would be designed to convey approximately one-half the base flood discharge of 3,100 cfs, similar to the overflow bypass alternative. Water surface elevations at East Bayshore Road would be within 0.1 foot of those predicted for the overflow bypass.

Environmental and Ecological Impacts. Construction activities would include temporary encroachment onto City property along East Bayshore Road, temporary closure of East Bayshore Road to through traffic, access problems during construction, and general construction disturbance. The relocation of several utilities (water, gas, storm drain, high pressure gas, sanitary sewer, street lighting, and possibly others) might disrupt local service. Minor impacts to jurisdictional areas may occur at the sediment basin and outfall.

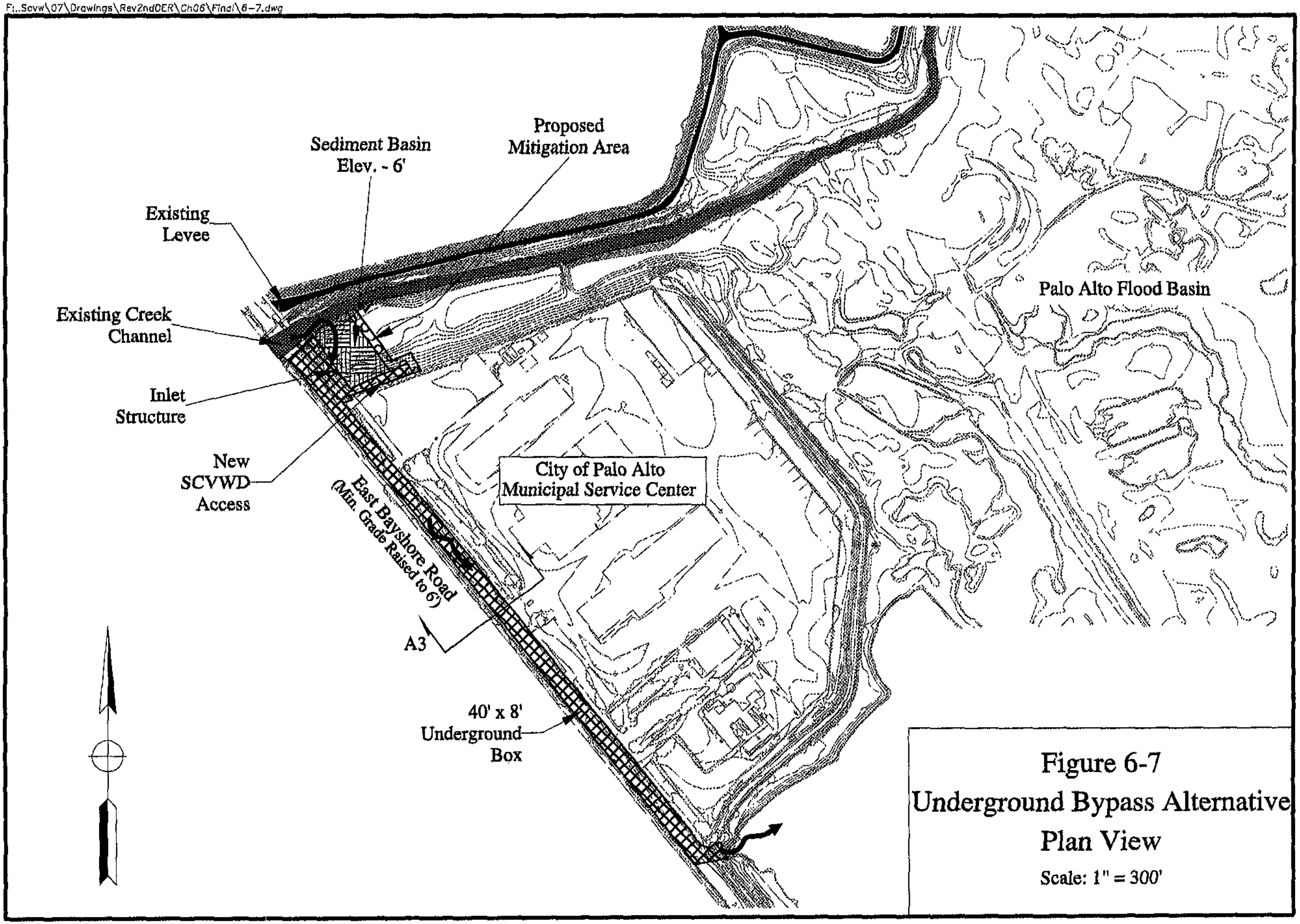

Figure 6-7
Underground Bypass Alternative
Plan View

Scale: 1" = 300'

Schaaf & Wheeler

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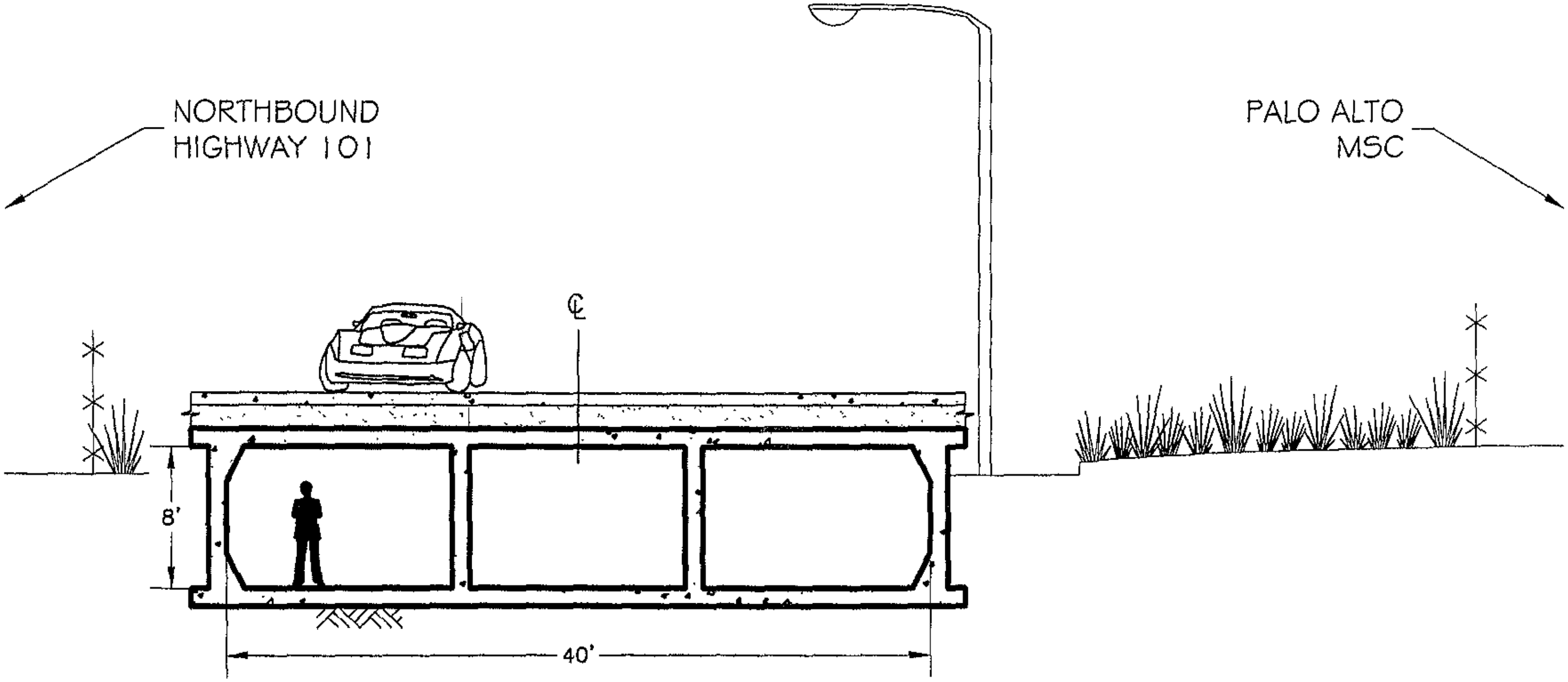

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Figure 6-8
Underground Bypass Alternative

Schaaf & Wheeler

Approximately 0.42 acres of riparian habitat near the location of the proposed sediment basin would be impacted by the underground bypass alternative. With proper construction practices, there should be minimal impact to wetland habitat. Some wetland vegetation would be impacted immediately downstream of Highway 101, which could result in the loss of suitable habitat for the San Francisco garter snake if it is present in that area. No pickleweed is present within the impact areas for this alternative, and, therefore, it is unlikely that salt marsh harvest mouse habitat would be impacted. Timing of the construction work would have to be arranged carefully so as to minimize impacts to birds' and waterfowl breeding and nesting activities. Some bird species, such as the cliff swallows that nest under the bridges by Highway 101, would likely abandon their nests due to construction disturbance.

Mitigation to offset environmental impacts is tabulated below. A total of 1.08 acres of riparian mitigation would be provided for this alternative. Insufficient acreage is available adjacent to the MSC levees to provide this mitigation. The highest ranked mitigation site, Site A (International School), is proposed for this project alternative.

Table 6-4
Impacts and Mitigation for Underground Bypass Alternative

		Mitigation		
Habitat	*Impact (ac)*	*On-Site (ac)*	*Off-Site (ac)*	*Total (ac)*
Willow Riparian	0.42	0.01	1.07	1.08
Freshwater Marsh	<0.01	0.00	0.00	0.00
TOTAL	0.42	0.01	1.07	1.08

Geotechnical and Hazardous Materials Impacts. Material that would be removed during channel excavation contains organics, would be very saturated, and must be hauled to a suitable disposable area. Construction dewatering would be necessary during channel excavation. The existing channel subgrade is anticipated to consist of soft and saturated clay materials. Bridging materials would be required within the dewatered channel to support construction traffic and structures. Excavation shoring is required because of the limited right-of-way. Based on investigations, significant hazardous materials issues are not anticipated for this alternative.

Structural Engineering Considerations. Construction of the proposed concrete box culvert would require at least three construction/traffic control stages to maintain access to the existing MSC and the Animal Services Center. At each stage, temporary sheet piling would be driven along both sides of East Bayshore Road to retain the sides of the 12- to 16-foot excavations, limit groundwater infiltration and facilitate dewatering during construction. A suitable working platform for construction equipment would consist of installation of drain rock/bridging material overlaying geotextile stabilization fabric along the culvert invert.

Utility relocation would be a significant element of the culvert design and construction. Based on as-built plans provided by the City and notes from field review, the assumed utilities along East Bayshore Road that must be relocated include City street lighting; a 20-inch PG&E high pressure gas main; an 18-inch sanitary sewer; a 10-inch water line; a 4-inch gas line; overhead power lines; various catch basins and storm drains; and branch lines for water, gas and sewer lines running to the MSC and the Animal Services Center.

Right-of-Way Considerations. Construction of the sediment basin would occur within the easement granted to the District by the City of Palo Alto in 1967 for the purposes of flood control. Temporary construction easements would have to be obtained from the City of Palo Alto to allow closure of East Bayshore Road and multi-stage construction. Utilities would have to be permanently relocated outside of the existing East Bayshore right-of-way, thus requiring utility easement acquisition. Possible utility relocation sites would be on City property closer to the MSC outside of the construction footprint, or within the Caltrans right-of-way along U.S. 101 and the existing bridges across Matadero Creek.

Maintenance Impacts. District personnel would regularly remove sediment and debris from the underground box culvert to maintain its conveyance capacity. Once average sediment depth exceeds one foot, hydraulic performance is compromised. The culvert will need to be cleaned once 2,200 cubic yards of sediment have accumulated, or every three years on average. The 8-foot culvert height would allow maintenance activities to be mechanized. However, provisions for work within a confined and hazardous space would have to be followed. Appendix E contains an estimate of annual maintenance costs for this reach alternative, and how they compare to maintenance costs for other alternatives. Because of the confined working conditions relative to the overflow bypass, which is in the open, life-cycle maintenance costs for this alternative are higher.

Estimated Costs. Table 6-5 summarizes estimated construction costs for the underground bypass alternative. The present worth of annual maintenance costs for this alternative is $860,000. Appendix E provides further details.

Table 6-5
Estimated Costs for Underground Bypass Alternative

Project Element	*Estimated Cost*
Construction	$11,300,000
Mitigation Work	$200,000
Land Acquisition for Utilities	$250,000
Contingencies	$3,250,000
TOTAL COST	**$15,000,000**

Channel Restoration Alternative

This project alternative would increase flow conveyance by removing sediments that have accumulated in the channel after original levee construction in 1971. Vegetation clearing and channel re-excavation would occur entirely within the easement granted to the District by the City of Palo Alto in 1967 for flood control.

Project Description. Vegetation and approximately 20,000 cubic yards of established sediment must be hauled off-site. Figure 6-9 shows a cross section of the material that must be removed to return the channel reach to its 1971 "as-built" condition. Figure 6-10 shows the plan view of the limit of work to restore Matadero Creek capacity in this reach.

Hydraulic Performance. Initially, the restored channel would perform as assumed in the 1988 Engineer's Report, and the design water surface elevation at Bayshore Freeway would be less than 6 feet NGVD'29. Eventually, however, hydraulic performance would deteriorate as sediments began to accumulate. To maintain the intended function of the channel, the acceptable maintenance limit for sediment levels within the south overbank would be -2 feet ± NGVD'29.

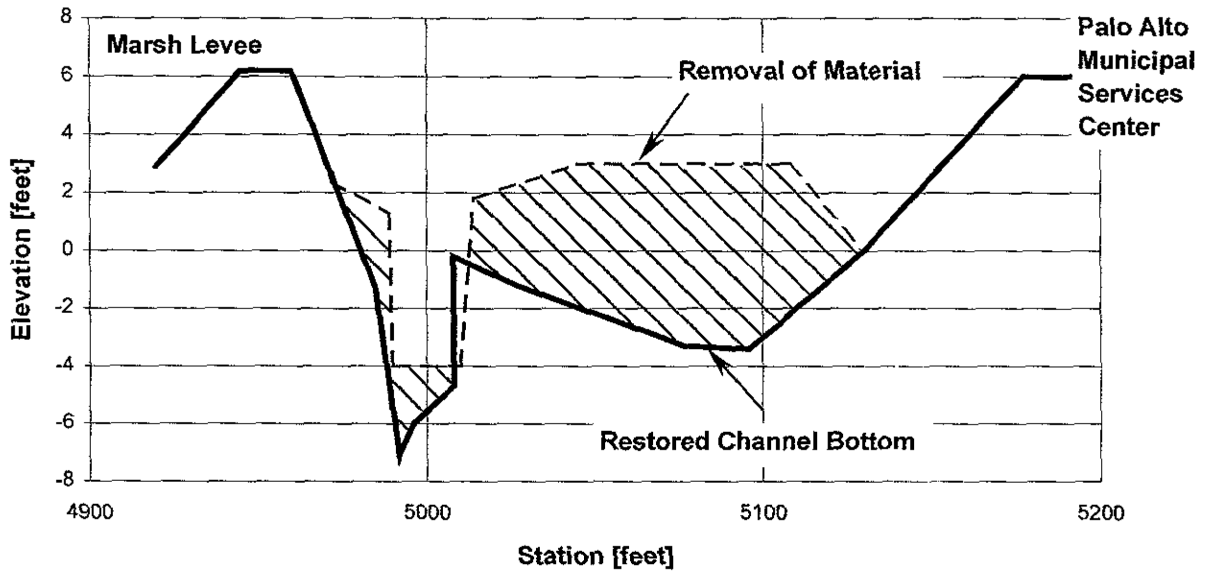

Figure 6-9. Channel Restoration Alternative

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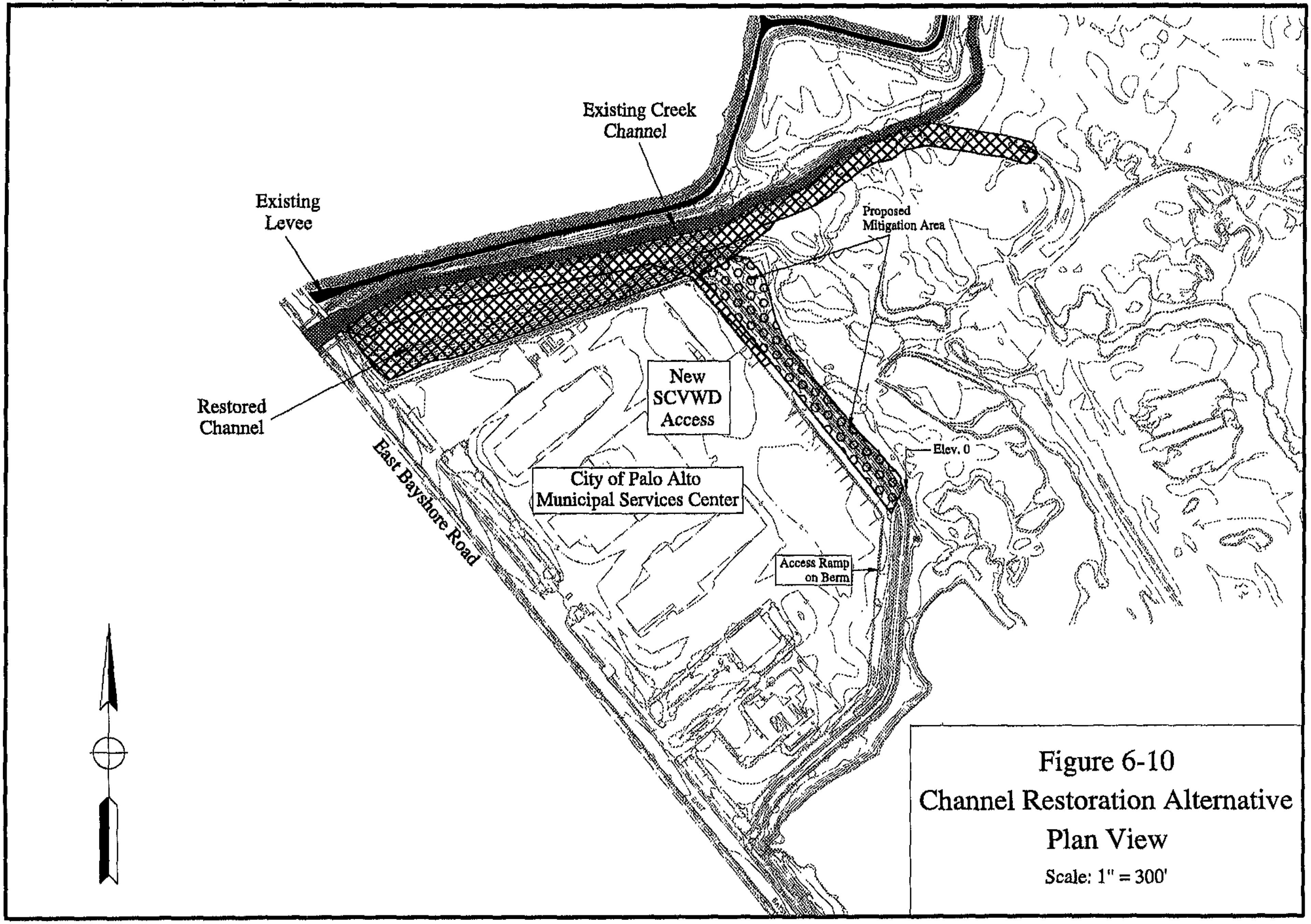

Figure 6-10
Channel Restoration Alternative
Plan View
Scale: 1" = 300'

Environmental/Ecological Impacts. This alternative results in the loss of the entire riparian corridor along the southern overbank area of Matadero Creek below Bayshore Freeway. Biological resources would be significantly and unavoidably impacted (Table 6-6). Constraints on project construction include the presence of several special-status wildlife species (San Francisco garter snake, salt marsh harvest mouse, steelhead rainbow trout) and several California Species of Special Concern. Construction specifications would be written to monitor and protect endangered species during summer breeding seasons. Bird nesting areas would also be impacted by construction.

Based on field surveys and aerial photographs, approximately 3.4 acres of riparian habitat would be impacted by this alternative. Habitats affected include willow riparian, ruderal, and coyote brush/scrub. At the mouth of the restored channel, 0.4 acres of wetlands would also be impacted. Table 6-6 presents the estimated impacts and mitigation for this alternative.

Table 6-6
Impacts and Mitigation for Channel Restoration Alternative

		Mitigation		
Habitat	***Impact (ac)***	***On-Site (ac)***	***Off-Site (ac)***	***Total (ac)***
Willow Riparian	3.36	0.00	10.08	10.08
Freshwater Marsh	0.66	1.32	0.00	1.32
Ruderal	0.12	0.00	0.12	0.12
TOTAL	4.14	1.32	10.20	11.52

All of the potential mitigation sites except Site D, Arastradero Road, would be developed to create riparian habitat as mitigation for this project alternative's impacts. Freshwater marsh areas would be created to mitigate impacts by removing about 700 feet of the northeasterly MSC levee adjacent to the PAFB and converting the area formerly occupied by the levee into a wetland habitat. A new bermed access road along the MSC fence would replace the flood protection currently provided by the levee.

Geotechnical and Hazardous Materials Impacts. Material that would be removed during channel excavation contains organics, would be very saturated, and should be hauled to a suitable disposable area. Construction dewatering will be necessary during channel excavation. The existing channel subgrade is anticipated to consist of soft and saturated clay materials. Bridging materials would be required within the dewatered channel to support construction traffic.

Fuel spill contamination has been found on the adjacent MSC property. The impact of this contaminated soil is identical to the Overflow Bypass Alternative.

Maintenance Impacts. To meet hydraulic performance standards in this reach, the acceptable maintenance limit for sediment levels within the south overbank is -2 feet ± NGVD'29, corresponding to about 1,500 cubic yards of sediment accumulation. At average rates of deposition, the channel would need to be cleaned every other year. The south overbank area is sufficiently large to preclude sediment removal from the adjacent Palo Alto Municipal Services Center or from the north bank levee that borders Renzel Marsh. Consequently, sediment must be removed from within the overbank area itself. With this project alternative, this reach is subject to partial inundation from groundwater throughout the year. Groundwater levels monitored during the past two years indicate that the local summertime water table would have to be lowered by dewatering to provide a driveable surface for conventional track-equipped sediment removal vehicles.

Community Impacts. City of Palo Alto staff and many people in the audience at public forums have expressed support for this project alternative. Members of the environmental community have echoed representatives from permitting agencies, stating that they do not support this project alternative because of the significant impacts to the high-quality riparian habitat.

Estimated Costs. Table 6-7 summarizes estimated costs for this reach alternative. Detailed alternative project cost estimation is provided in Appendix E. Based on Table 6-1, 7.2 acres of land must be acquired through purchase or lease to provide adequate mitigation. The present worth of annual maintenance costs for this alternative is $710,000.

Table 6-7
Estimated Costs for Channel Restoration Alternative

Project Element	*Estimated Cost*
Construction	$1,650,000
Mitigation Work	$2,150,000
Land Acquisition for Mitigation	$10,200,000
Contingencies	$3,500,000
TOTAL COST	**$17,500,000**

Expanded Floodway Alternative

Similar in nature to the Channel Restoration Alternative, this project alternative would restore flood flow conveyance downstream of Highway 101, but in a more compact channel section in order to reduce the impacts to habitat, and consequent mitigation requirements. All work would occur within the easement granted to the District by the City of Palo Alto in 1967.

Project Description. A 50-foot swath of silt deposits and vegetative growth would be removed adjacent to the existing low-flow maintenance channel to provide a 70-foot wide floodway, as shown in cross section by Figure 6-11. This floodway would begin just downstream of the bicycle/pedestrian bridge adjacent to East Bayshore Road, extend approximately 1,600 feet toward the Palo Alto Flood Basin, and veer to the southeast, discharging ~~to~~ the PAFB at open water below elevation 0.0 feet NGVD'29 (Figure 6-12). Mitigation areas along the project site would be replanted with an appropriate combination of native riparian vegetation.

The low-flow channel would no longer carry flow with sufficient velocity to maintain itself in this configuration; therefore, sediment would need to be removed periodically from the channel bottom in order to maintain full capacity. The expanded 50-foot floodway would also require regular sediment removal and clearing of any vegetation that becomes established. For these reasons, the bottom of the restored floodway would need to be covered with a hard maintenance floor that would allow access to remove accumulated sediment and vegetation. Most maintenance work would likely occur under wet conditions. A wall (possibly a gabion or other "soft" structure) would be built along the edge of the expanded floodway, and riparian habitat would be created/restored for the remaining area between the floodway and the MSC.

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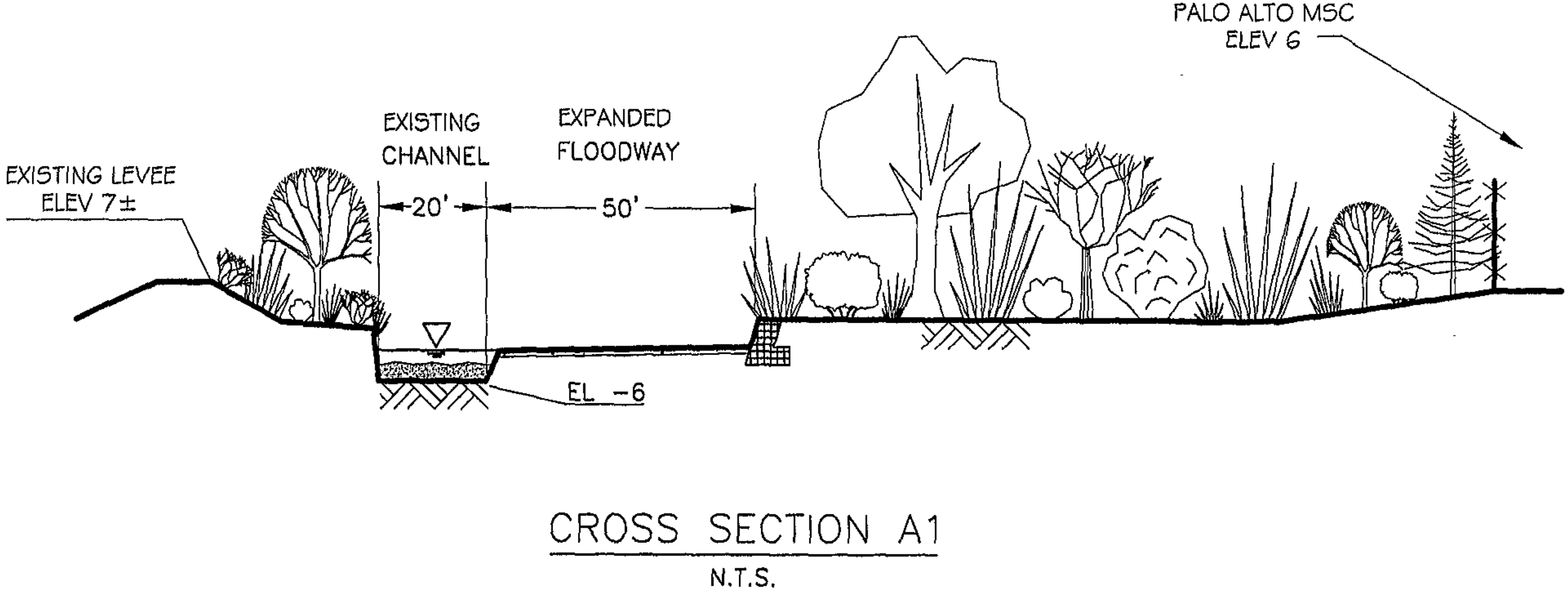

Figure 6-11
Expanded Floodway Alternative
Cross-Sectional View

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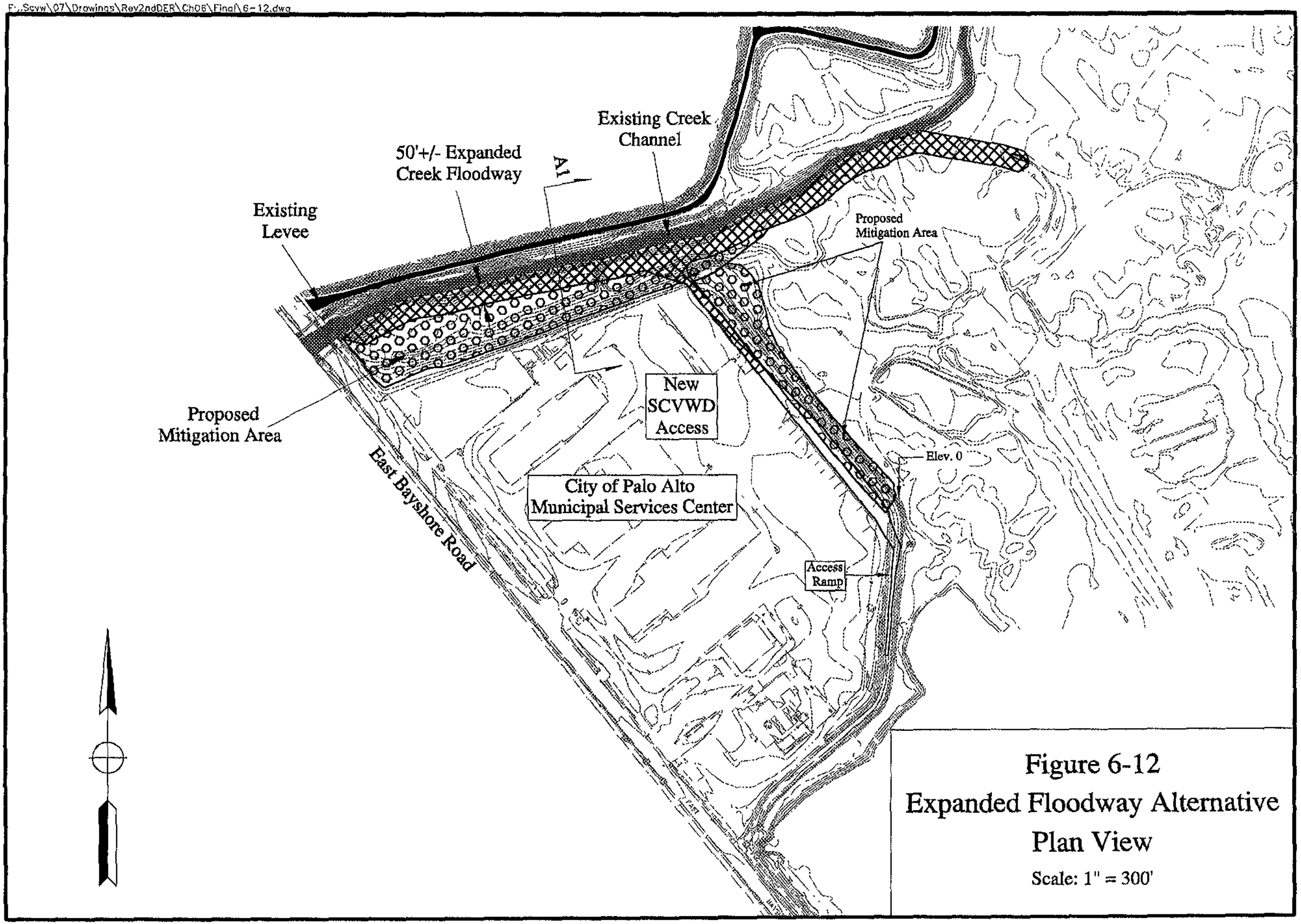


Figure 6-12
Expanded Floodway Alternative
Plan View
Scale: 1" = 300'

Hydraulic Performance. From a hydraulic perspective, this alternative would provide a direct means of expanding conveyance capacity within this reach of Matadero Creek. The expanded floodway would enable the channel to more efficiently convey the one-percent flowrate of 3,100 cfs. Hydraulic analyses indicate that such a measure would reduce backwater impacts at Highway 101 by 1.6 feet (to elevation 5.6 feet NGVD'29) relative to existing conditions.

Environmental and Ecological Impacts. This alternative would result in a substantial, though less extensive loss of the same riparian habitat described for the channel restoration alternative. Although the habitat loss would not result in significant visual or aesthetic impact due to the location of the proposed work, the biological resources would be significantly and unavoidably impacted. Construction impacts would include noise, dust, and general disturbance.

Based on conceptual plans, approximately 3.16 acres of riparian habitat would be impacted by this alternative. This alternative also would impact about 0.40 acres of high quality wetlands at the lower reaches of the expanded creek channel. Table 6-8 provides a summary of estimated impacts and mitigation acreage for this alternative.

Table 6-8
Impacts and Mitigation for Expanded Floodway Alternative

		Mitigation		
Habitat	*Impact (ac)*	*On-Site (ac)*	*Off-Site (ac)*	*Total (ac)*
Willow Riparian	3.16	1.63	7.85	9.48
Freshwater Marsh	0.40	0.80	0.00	0.80
Ruderal	0.09	0.00	0.09	0.09
TOTAL	3.65	2.43	7.94	10.37

On-site mitigation opportunities are available with this alternative, comprised mainly of the large area between the expanded channel and the MSC. This area is currently overgrown with invasive, non-native species such as Arunda. There is no net increase in riparian habitat associated with Matadero Creek on site, however, so additional riparian mitigation areas off-site will be used, including Site A (International School) and Site B (Stanford Pasture).

Geotechnical and Hazardous Materials Impacts. Geotechnical and hazardous materials impacts would not differ from those discussed for the channel restoration alternative. Any necessary retaining walls to facilitate maintenance access would be founded below the Bay mud, and local soils would be evaluated during the design period.

Maintenance Impacts. A maintenance access road would be created to the east of the MSC where an existing levee protects the MSC from flooding. This access is critical for performing channel maintenance work. To sustain hydraulic performance over time, no more than two feet of sediment could be allowed to accumulate either in the low-flow channel or the expanded floodway section. This allows 4,000 cubic yards of sediment to accumulate between scheduled cleanings, which should be necessary every five years on average. After the project is completed, the 20-foot wide low-flow channel and the expanded 50-foot wide floodway would be maintained clear of vegetation and sediment. The floodway would be constructed with a driveable surface to allow vehicular access for clearing sediment deposits using conventional tracked sediment removal equipment.

Estimated Costs. Table 6-9 summarizes estimated costs for the expanded floodway alternative, noting that 5.76 acres of land must be leased to provide mitigation areas. (See Appendix E.) The present worth cost of annual maintenance for this alternative is $660,000.

Table 6-9
Estimated Costs for Expanded Floodway Alternative

Project Element	*Estimated Cost*
Construction	$1,750,000
Mitigation Work	$1,950,000
Land Acquisition for Mitigation	$7,750,000
Contingencies	$3,050,000
TOTAL COST	**$14,500,000**

REACH 1 PROJECT SELECTION

The Overflow Bypass Alternative has been selected in this reach as the preferred remediation plan based on a comparison of costs, environmental impacts, community input, and effectiveness in addressing concerns. Of the feasible alternatives analyzed, its capital costs are about 50 percent less than for the second most cost-effective alternative. Table 6-10 summarizes the evaluation of feasible alternatives within Reach 1.

The underground bypass channel alternative was not selected because although its environmental impact is one-half of an acre less than the preferred plan's impact, both alternatives' impacts would be mitigated by planting on the highest ranked mitigation site, Site A — International School. The capital cost of this alternative is nearly double that of the preferred plan. Maintaining this alternative's facilities requires confined space entry and hazardous working conditions, whereas maintenance of the preferred plan does not.

The channel restoration alternative was not selected because it impacts 4.14 acres of habitat (more than four times the preferred plan's impact), and costs $17.5 million compared to $8 million for the preferred plan. Maintenance for this alternative is also more difficult than for the preferred plan.

The expanded floodway alternative was not selected because it impacts 3.65 acres of habitat (more than four times the preferred plan's impact), and costs $14.5 million compared to $8 million for the preferred plan. Maintenance for this alternative is also more difficult than for the preferred plan.

Table 6-10
Comparative Summary of Feasible Reach 1 Alternatives
Palo Alto Flood Basin to Highway 101

Issues and Concerns	Channel Restoration	Expanded Floodway	Overflow Bypass	Underground Bypass
1. Project Cost Estimate				
A. Construction	$ 1.7M	$ 1.8M	$ 5.7M	$ 11.3M
B. Mitigation Work	$ 2.1M	$ 2.0M	$ 0.5M	$ 0.2M
C. Construction R/W	$ 0.0M	$ 0.0M	$ 0.2M	$ 0.2M
D. Mitigation R/W	$ 10.2M	$ 7.7M	$ 0.0M	$ 0.0M
E. Contingency	$ 3.5M	$ 3.0M	$ 1.6M	$ 3.3M
E. Total Cost	**$ 17.5M**	**$ 14.5M**	**$ 8.0M**	**$ 15.0M**
2. Physical Environment				
A. General Description	20,000 cy ± of material would be removed from Matadero Creek D/S of Highway 101 to restore flood flow conveyance.	50-ft wide channel excavated adjacent to Matadero Creek to restore flood flow conveyance.	60' wide high flow bypass parallel to Matadero Creek along MSC boundary.	40' x 8' box culvert under E. Bayshore to convey high flows from Matadero Creek to the PAFB south of MSC.
B. Erosion	Reach will continue to be area of sediment deposition..	Reach will continue to be area of sediment deposition.	Overflow bypass construction resistant to erosion.	Box culvert will not induce additional erosion.
C. Sedimentation	Increased sedimentation in PAFB due to improved conveyance in Matadero Creek.	Increased sedimentation in PAFB due to improved conveyance in Matadero Creek	Sedimentation will occur in bypass channel during high flow events	Sedimentation will occur in box culvert during high flow events.
D. Water Quality	No impact..	No impact.	No impact.	No impact.
E. Maintenance	Regular removal of vegetation & sediment from channel. **PW Cost = $700,000**	Regular removal of vegetation & sediment from channel/floodway. **PW Cost = $650,000**	Regular removal of sediment from bypass. Regular removal of vegetation from creek channel. **PW Cost = $500,000**	Regular removal of sediment from bypass. Regular removal of vegetation from creek channel. **PW Cost = $850,000**
3. Biological Environment				
A. Fish Habitat	Potential impact during routine maintenance.	Potential impact during routine maintenance.	No post-construction impact.	No post-construction impact.
B. Wildlife Habitat	Destruction of riparian and wetland habitats.	Destruction of riparian and wetland habitats.	Destruction of riparian and wetland habitats.	Destruction of riparian habitat.
C. Wetlands Impact	0.7 acres	0.4 acres	0.1 acres	<0.01 acres
D. Riparian Impact	3.4 acres	3.2 acres	0.8 acres	0.4 acres

REACH 2 - HIGHWAY 101 TO ALMA STREET

Feasible projects in this reach of Matadero Creek would accomplish project objectives by conveying the full design base flood with adequate freeboard, using some combination of one or more of the following project alternatives:

1) An increase in floodwall heights as necessary to provide adequate freeboard; and/or
2) Channel modifications to carry more flow at the same depth; and/or
3) Bridge modifications to reduce the energy lost through existing openings.

Feasible alternative remediation projects that provide flood protection at NIP standards by increasing conveyance between Highway 101 and Alma Street are described and evaluated herein.

Raising Floodwalls. To provide freeboard meeting the objectives set forth in Chapter 2, it will be necessary to raise existing floodwalls for at least some portion of the channel for any of the proposed remediation alternatives. Floodwall types vary throughout the reach by wall type, material and condition.

Channel Modifications. Flow conveyance is generally improved by adding more cross-sectional area to the channel. One method is to raise floodwalls and add this area by increasing the depth of flow. Another is to widen or deepen the channel to add more area at the same depth of flow. Since the Matadero Creek right-of-way is limited and a buried high voltage electrical transmission line parallels the creek very close to its northern bank, channel widening would be limited to modifying the channel shape from trapezoidal to rectangular. The 1988 flood protection project did make this modification to the channel between the SPRR and El Camino Real, using the construction of a so-called "U frame" concrete channel (Photo 2-6).

Temporary shoring would be required to support the creek bank during construction, particularly near the buried high voltage electrical transmission line. The old concrete channel lining would be demolished, and the "U" shape excavated between the temporary supports. Concrete walls and a bottom slab would then be poured to form the U-frame channel. (After backfilling, the shoring could be removed or left in place.) Such District channel sections also typically include a low-flow channel to avoid stagnant water during the dry season.

Bridge Modifications. As explained in Chapter 5, backwater effects at Louis Road could be lessened by increasing the area of bridge opening acting as a flow orifice, and correspondingly reducing energy losses through the bridge. The bridge opening can be enlarged by modifying the creek channel in this reach from a trapezoidal shape to a "U-frame" shape and/or raising the bridge superstructure itself. Based on information presented in Chapter 5, Louis Road could be raised by no more than one foot at Matadero Creek.

Feasible Alternative Combinations. Two basic methods for increasing channel conveyance to meet stated project objectives between Greer Road and Alma Street are explored in this chapter:

> **Floodwall Alternative** — seeks to minimize the scope of in-channel modification by increasing the elevation of existing floodwalls to provide additional conveyance and/or freeboard.
>
> **Channel Alternative** — seeks to minimize increases in floodwall heights necessary to provide adequate freeboard by maximizing increased conveyance through in-channel modifications.

As discussed herein, enlarging the channel does not obviate the need for some floodwall improvements, particularly close to Greer Road and Louis Road.

Floodwall Alternative

Modifying the Matadero Creek channel within a limited right-of-way and in close proximity to a major utility (whose repair for damages could cost millions) is a costly, time consuming, disruptive, and risky endeavor. This alternative addresses remedial activities that would limit the amount of in-channel modification. This alternative combines the following project components in this reach:

1) In the immediate vicinity of the Louis Road bridge, replace the concrete trapezoidal channel with a concrete "U-frame" channel.
2) Replace the Louis Road bridge superstructure at a higher elevation;
3) Improve the culvert-to-channel transition downstream of the Southern Pacific Railroad; and
4) Raise floodwalls as required to meet FEMA approval.

Project Description. To improve hydraulic performance at the Louis Road bridge, the existing trapezoidal channel directly under the bridge would be replaced with a full U-frame channel section along the same alignment. The U-frame channel would be 36 feet wide to match the existing floodwall-to-floodwall width. A 40-foot long transition from trapezoidal shape to rectangular shape would be provided upstream of the bridge and a 20-foot long transition from rectangular-to-trapezoidal shape would be constructed on the downstream side. Channel modifications adjacent to the bridge also include the replacement of any existing floodwalls impacted by construction, necessary modifications to the existing maintenance access ramp on the downstream side of Louis Road, and an extension of the existing fish passage channel throughout the new construction.

The Louis Road bridge is not sufficiently reinforced to safely handle hydrostatic loading during the design event. There may also be the opportunity to improve bridge hydraulics at the same time. Field surveys indicate that Louis Road may be raised vertically by about one foot at Matadero Creek and remain within design standards for roadway sight distance and drainage.

Finally, flow characteristics at the Alma Street culvert are influenced by its downstream channel transition configuration (Photo 2-7). The abrupt transition at the culvert's downstream face causes the culvert to flow under an outlet control condition with the base flood discharge. By providing a new warped transition from the culvert to the easterly channel bank, the culvert would flow under inlet control conditions with a lower headwater elevation. Over one foot of water surface elevation relief will be realized at the culvert by providing a new warped transition downstream of Alma.

Hydraulic Performance. By replacing and raising the Louis Road bridge, modifying the channel at Louis Road, and improving the downstream transition at Alma Street, Matadero Creek could discharge the design one-percent flood without overtopping any of the existing floodwalls. The channel, however, would be brim-full at both Louis Road and Waverley Street. Although in one sense this remedial action provides one-percent flood protection, NFIP and District standards for freeboard are still not met between West Bayshore Road and Middlefield Road and just upstream from Waverley Street.

The improvement of hydraulic performance in response to various in-channel remediation projects may be measured by examining the resulting reductions in required floodwall heights to meet FEMA and District freeboard standards. Prior to comparing the potential in-channel alternatives, a clear understanding of the nomenclature of headwalls and floodwalls is helpful.

Figure 6-13 shows an isometric view of a bridge crossing with distinctions between headwalls and floodwalls. As shown in this Figure, "headwall" refers to the portion of a floodwall that wraps around each bridge face and continues for 100 feet upstream (or downstream) of the bridge. FEMA requires one additional foot of freeboard (a total of 4 feet) at every bridge crossing, and for 100 feet upstream and downstream of each crossing, when the one-percent flood is carried above the natural bank elevation. As depicted in Figure 6-13, the height of the headwall, HH, is measured from the sidewalk adjacent to the bridge face. Table 6-11 presents the required headwall heights (HH) at both the downstream and upstream face of the bridge crossings on Matadero Creek. These heights are measured from the existing sidewalk on the bridges, and are presented for four scenarios:

A: Existing conditions;

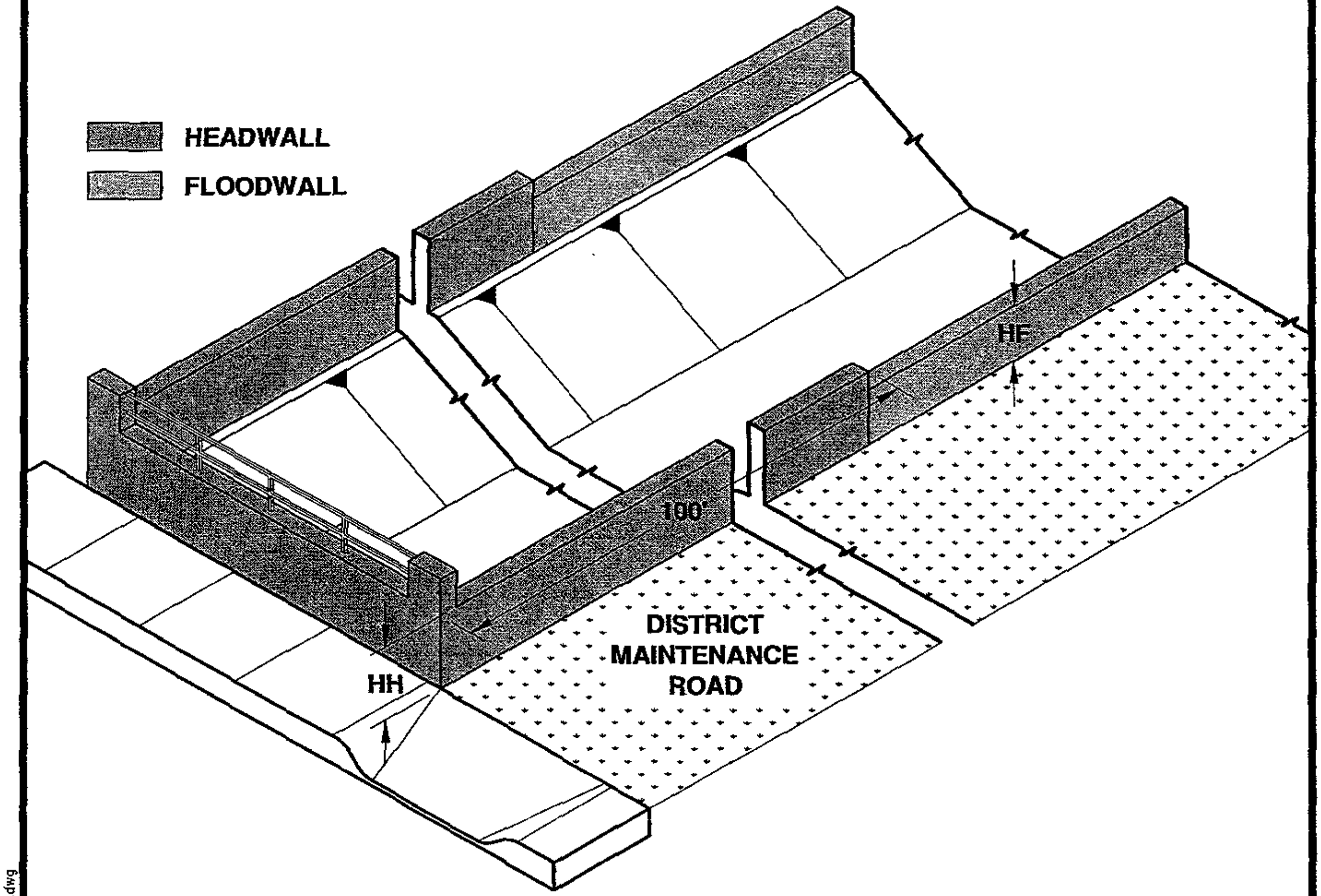
B: Baseline scenario, which represents a potential project that would involve only raising floodwalls in Reach 2 along with the completion of improvements in Reach 1 downstream of Highway 101;

C: The baseline scenario (B) plus limited channel modifications, which would include:
  1) Replacement of the Louis Road Bridge;
  2) Modifying the channel section at Louis Road from a trapezoidal shape to a "U-frame"; and
  3) Providing a new transition at the Alma Street culvert;

D: Scenario C with the added element of raising the Louis Road Bridge by one (1) foot;

As Table 6-11 shows, combining the improvements in Reach 1 with only floodwall raising (Scenario B) would result in excessive headwall heights on the upstream side of Greer, Louis and Ross Road Bridges. By adding the limited channel modifications (Scenario C), the required headwall heights drop somewhat at both Louis and Ross Road Bridges, but are still nearly seven feet high at the Greer Road Bridge.

Since the Louis Road Bridge must be replaced due to structural inadequacy, Scenario D in Table 6-11 reflects the required headwall heights if this bridge is also raised by one foot when it is replaced. Although this measure will significantly improve the required headwall height at Louis Road Bridge, the headwall height requirement at the upstream face of Greer Road is still close to seven feet.



HH = Height of Headwall above sidewalk to meet FEMA's freeboard criterion of 4.0 feet at bridge crossings.

HF = Height of floodwalls above natural ground to meet FEMA's freeboard criterion of 3.0 feet along a creek channel.

Figure 6-13: Headwall and Floodwall Detail

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Table 6-11
Headwall Heights (HH) Required to meet FEMA Standards for Reach 2 Floodwall Alternative Options

	A: Existing			*B: Baseline Condition (Reach 1 Improvements)*		*C: B plus Limited Channel Modifications*		*D: B plus C plus Raise Louis Rd Bridge 12 inches*	
Location	Sidewalk Elevation (ft NGVD'29)	Headwall Elevation (ft NGVD'29)	Headwall Height (feet)	WSEL (ft NGVD'29)	Required Headwall Height (feet)	WSEL (ft NGVD'29)	Required Headwall Height (feet)	WSEL (ft NGVD'29)	Required Headwall Height (feet)
W Bayshore Rd	9.8	10.5	0.7	5.71	0.7	5.71	0.7	5.71	0.7
D/S Greer Rd	6.2	9.3	3.1	7.90	5.7	7.90	5.7	7.90	5.7
U/S Greer Rd	6.2	10.0	3.8	8.81	6.6	8.81	6.6	8.81	6.6
D/S Louis Rd	8.4	10.6	2.2	8.83	4.4	9.26	4.9	9.26	3.9
U/S Louis Rd	8.4	11.2	2.8	12.69	8.3	10.78	6.4	10.22	4.8
D/S Ross Rd	13.2	15.5	2.3	12.90	3.7	11.19	2.3	11.21	2.3
U/S Ross Rd	13.2	15.5	2.3	14.63	5.4	12.29	3.1	12.32	3.1
D/S Middlefield Rd	16.7	19.0	2.3	14.97	2.3	14.08	2.3	14.14	2.3
U/S Middlefield Rd	16.7	19.0	2.3	16.13	3.4	14.48	2.3	14.64	2.3
D/S Cowper St	19.4	21.8	2.4	16.93	2.4	16.94	2.4	16.94	2.4
U/S Cowper St	19.4	21.8	2.4	18.25	2.4	18.28	2.4	18.28	2.4
D/S Waverley St	21.2	23.4	2.2	19.51	2.2	19.52	2.2	19.52	2.2
U/S Waverley St	21.2	23.4	2.2	20.90	3.7	20.91	3.7	20.91	3.7
Alma St	24.4	25.0	0.6	23.29	0.6	22.04	0.6	22.04	0.6
SPRR	29.5	29.6	0.1	26.53	1.0	25.05	0.1	25.05	0.1

(A similar analysis at Waverley Street shows that by modifying the channel shape from trapezoidal to "U-frame" at this location and raising the bridge by 12 inches, the water surface elevation and requisite headwall elevation are lowered by 0.4 foot. The disruption and cost of channel and bridge modifications at Waverley Street do not appear to be warranted.)

Figure 6-13 also depicts the floodwall heights (HF) required along creek banks, which are measured from the adjacent natural ground elevation, either on the north or south bank of the creek, whichever is lower. According to FEMA criteria, floodwalls along the creek bank are required to provide 3 feet of freeboard when the one-percent flood is carried above the natural bank elevation. Table 6-12 presents required floodwall heights along Matadero Creek in Reach 2 to meet FEMA requirements for the same four scenarios (A through D) described earlier.

Table 6-12
Floodwall Heights (HF) Required to meet FEMA Standards for Reach 2 Floodwall Alternative Options

	Range of Floodwall Heights in Feet as Measured from Lowest Adjacent Grade			
Reach	A: Existing Walls	B: Baseline Condition (Reach 1 Improvements)	C: B plus Limited Channel Modifications	D: B plus C plus Raise Louis Rd Bridge 12 inches
W Bayshore to Greer	2 to 4	2 to 5	2 to 5	2 to 5
Greer to Louis	2 to 3	4 to 5	4 to 5	4 to 5
Louis to Ross	2 to 3	6 to 7	4 to 6	4 to 6
Ross to Middlefield	2 to 3	6 to 7	4 to 5	4 to 5
Middlefield to Cowper	1 to 2	1 to 4	1 to 2	1 to 2
Cowper to Waverley	0 to 1	2 to 3	2 to 3	2 to 3
Waverley to Bryant	1 to 2	1 to 3	1 to 3	1 to 3
Bryant to Alma	0 to 1	0 to 1	0 to 1	0 to 1
SPRR to Park	1 to 3	1 to 4	1 to 3	1 to 3
Park to Lambert	1 to 2	1 to 3	1 to 2	1 to 2
Lambert to El Camino	1 to 2	1 to 2	1 to 2	1 to 2

For Scenario B, with the completion of the downstream Reach 1 improvements, the floodwall heights between West Bayshore Road and Louis Road will have to be raised by up to two feet, and must increase by approximately four feet between Louis Road and Middlefield Road to meet FEMA standards. For Scenario C, the added channel and bridge modifications at Louis Road will reduce the increase in floodwall heights by 50 percent (two feet). Reductions in required floodwall heights due to the Louis Road bridge modifications can be noted as far upstream at Cowper Street.

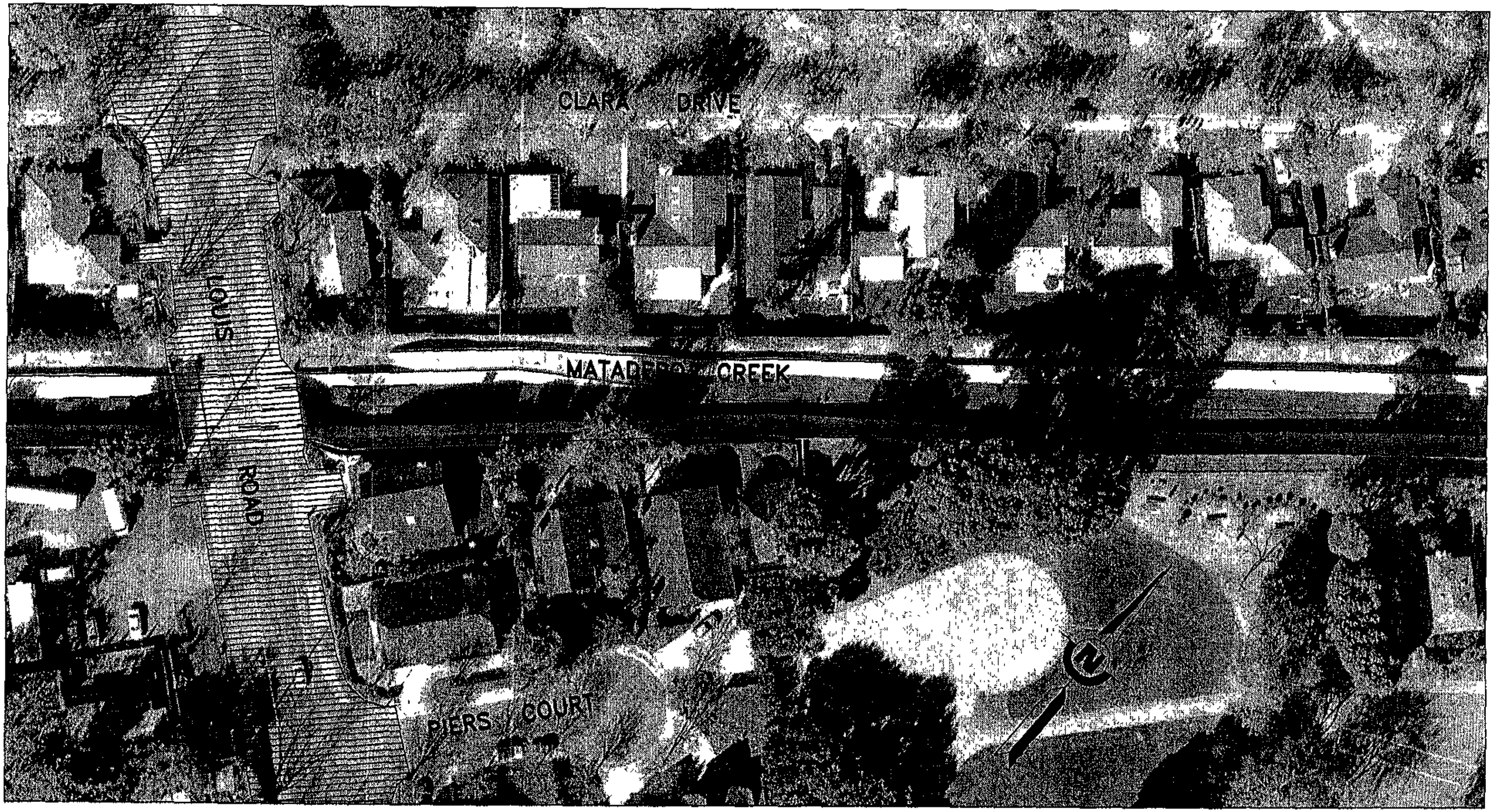
Proposed modifications to the transition just downstream of Alma Street/SPRR culvert eliminate the need to raise floodwalls between the railroad and Lambert Avenue by one foot.

Environmental and Ecological Impacts. Construction for this alternative would take place within the concrete-lined portion of the existing Matadero Creek channel or its right-of-way. Work is not expected to result in a significant impact to any habitat (Powers & Associates, 2001). Floodwall construction would take place above the natural bank, outside of the channel, where habitat disturbance is also minimal.

Roadway and Traffic Impacts. Changes to the Louis Road profile are desirable to provide the greatest degree of flood risk remediation for this alternative project. Louis Road is classified by the City of Palo Alto as a collector street. For this level of service in a highly developed area on ordinary terrain (35 mph design speed), maximum recommended street grade is four percent with a minimum horizontal sight distance of 250 feet. (Wright and Paquette, 1979)

To raise Louis Road by one foot at the creek crossing, a 200-foot long vertical curve with a 1.9 percent approach from the north beginning at Piers Court, and a 2.6 percent approach from the south beginning at Clara Drive could be feasible. Under this preliminary design, the calculated sight distance is 255 feet. (Wright and Paquette, 1979)

Figure 6-14 shows an aerial view of the portion of Louis Road between Piers Court and Clara Drive that could potentially be impacted by changes to the road profile. In particular, Chabad Center's new driveway has a centerline only 40 feet from the centerline of Matadero Creek. (The aerial photograph in Figure 6-14 predates this driveway.) Preliminary road profiles that would facilitate raising the bridge soffit by 12 inches indicate that the grade at the Chabad Center driveway centerline would also be about one foot higher. Regrading the driveway would not be problematic, but maintaining a positive grade from the driveway to the street would no longer be possible. Some drainage would therefore be routed directly to the creek through a new flap-gated outfall.



Hatching Indicates Limits of Louis Road Reconstruction

Figure 6-14
Limits of Louis Road
Bridge Replacement

In addition to the Chabad Center driveway, there are three private driveways accessed from Louis Road between Piers Court and Clara Drive that would be affected by proposed changes to Louis Road. Of these, one driveway at the northeast corner of the Louis Road / Clara Drive intersection already drains back to the garage, so access and drainage would not be significantly affected by the proposed increase in street grade. Across the street on the west side of Louis Road, the driveway just drains toward the street, so proposed changes to the road profile would change the direction of drainage back toward this resident's garage. South of the bridge, the private driveway on the west side of the street now drains back to the street at a five-percent grade. Raising Louis Road would leave this driveway with positive drainage to the street, but at less than one-percent grade.

Temporary road closures and traffic detours would be necessary during the replacement of the Louis Road bridge, which is expected to last up to six months. Vehicular and pedestrian traffic would likely be routed to Greer Road and Ross Road via Loma Verde Avenue and Colorado Avenue. Once the bridge is reopened, however, vehicular and pedestrian traffic should return to existing patterns.

Eliminating the use of the Matadero Creek crossing for all but pedestrians and bicycles at Louis Road would significantly alter traffic patterns in this residential neighborhood. Although traffic and emergency access to all property can be maintained, the elimination of through traffic on Louis Road between Loma Verde and Colorado would inevitably increase traffic flow on Greer Road and Ross Road between the two cross streets. For these reasons, the City of Palo Alto has indicated that eliminating vehicular traffic on Louis Road at Matadero Creek is not acceptable .

Impacts to Local Drainage Conditions. The issue of preserving local site drainage characteristics is of great concern. Changes in a road profile that worsen "nuisance" ponding are not acceptable. Using topographic information from a limited 1999 site survey, it appears that increasing the grade along Louis Road from Piers Court north to Clara Drive by up to one foot would not significantly alter the site drainage at any affected properties. The safe overland release elevation for each property would not be changed to the point where the potential for flooding on-site during lesser events would be increased. Chabad Center has a drainage release along its southerly property, which would not be affected by the proposed Louis Road grade changes.

Similarly, the residence located across the street from Chabad Center would continue to positively drain to Louis Road. To the north, properties can still release to Clara Drive. During final design, additional surveys will be required to confirm the continued safe release of site drainage, and to establish whether additional storm drainage systems are required on individual properties to prevent nuisance runoff from being trapped in garages or other areas.

The implementation of the Floodwall Alternative would improve local drainage conditions somewhat between Louis Road and Cowper Street, because hydraulic improvements at Louis Road lessen water depths in the channel for most flooding conditions. Raising the walls does not adversely impact local drainage, because the walls are providing additional freeboard rather than raising the water surface elevation. This is particularly true for the ten-percent water surface, which local storm drain systems are usually designed to handle. Local drainage downstream of approximately Ross Road is not affected at all, since this local runoff is pumped into the creek.

Visual Impacts. As presented in Tables 6-11 and 6-12, implementing the Reach 2 Floodwall Alternative Option would result in significant visual changes along much of the project reach between Highway 101 and Alma Street. Between Greer Road and Middlefield Road, floodwall heights along Matadero Creek channel would increase by as much as two feet in order to meet FEMA and District freeboard requirements. Most of the impacted project reach is residential, and properties abut directly against the creek right-of-way in many places. For some residences, the floodwalls serve as defacto backyard fences. At Greer Road and Louis Road, higher headwalls would be more visually obstructive than they are now, and would limit views of the foothills to the southwest, and from some locations, views of the baylands to the northeast.

Matadero Creek, while not a natural stream between Bayshore and El Camino, "...could be considered an important scenic and aesthetic resource in this urban environment because it does contain trees and other riparian vegetation. The development of proposed floodwalls would block existing views of the creek channel from the roadway bridge crossings of Greer Road and Louis Road and would change the visual character of these roadways." (Powers & Associates, 2001)

Public outreach efforts indicate that floodwall height is one of the most sensitive issues with the Palo Alto community. The loss of views along the creek corridor associated with headwalls greater than seven feet above the sidewalk is a serious impact caused by proposed channel remediation. To partially mitigate this impact for the Floodwall Alternative, a procedure developed by FEMA and the U.S. Army Corps of Engineers to reduce required freeboard on federal projects has been submitted to FEMA for approval. The procedure is described in Appendix I. FEMA will consider freeboard reductions of up to two feet based partly on such statistical analysis, but under no circumstances will FEMA accept less than two feet of freeboard.

Structural Issues. Several structural engineering related issues must be considered during preliminary and final designs for this alternative. These issues also influence hydraulic performance decisions that need to be made in terms of the proposed level of remediation.

Design one-percent flood discharges will pressurize bridges at Greer Road, Louis Road, Ross Road, and Waverley Street. To provide freeboard, floodwalls extend above the natural channel banks at these locations. The design of structures for pressurized flow is typically based on a maximum water surface elevation equal to the available freeboard.

Based on an analysis of each structure's demand-to-capacity ratio under *existing* floodwall conditions, it has been determined that the Louis Road bridge is significantly overstressed (its demand-to-capacity ratio is nearly 2.4); bridges at Ross Road, Middlefield Road, and Cowper Street are marginally overstressed (with demand-to-capacity ratios between 1.0 and 1.4); and the bridges at Greer Road and Waverley Street are adequately designed to resist uplift loading conditions (demand-to-capacity ratios are 0.3 and 0.1, respectively).

If full FEMA/District freeboard is applied to the one-percent flood elevations, both the Louis Road bridge (demand to capacity ratio = 4.2+) and the Ross Road bridge (demand to capacity ratio = 2.1) would become significantly overstressed as a result. The Louis Road structure cannot accommodate additional uplift forces due to the increased headwall elevation necessary for this alternative. Therefore, under the Floodwall Alternative, the bridge superstructure must be replaced.

A refined structural analysis of the Ross Road bridge, which accounts for the hydraulic effect of raising the Louis Road bridge, indicates that though this structure has the potential to be overstressed when pressurized to a level equivalent to full FEMA/District freeboard loading, replacement of the structure is not necessary for the following reasons:

1) The duration of pressurized loading is short term (±2 hours);

2) Using a design loading condition with full freeboard applied to both the upstream and downstream headwalls is conservative; and

3) Potential overstresses are localized and the existing structural system is integrated, allowing for the redistribution of loads.

A preliminary structural analysis of the as-built floodwalls indicates that the following scope of floodwall modification will be required to implement the Floodwall Alternative:

- 3,750± linear feet of floodwall can be raised without providing additional structural modifications to the as-built walls.

- 9,850± linear feet of floodwall would need to be replaced and/or strengthened.
- 120± linear feet of floodwall would be replaced as part of the proposed channel modifications at Louis Road.

Seven bridge structures cross Matadero Creek between Highway 101 and Alma Street. Several of these structures are subject to pressurization during the base flood event, and require the extension of their headwalls to provide freeboard. Headwall improvements are required at Greer Road, Ross Road, and Waverley Street. Headwalls at Louis Road will be replaced.

Maintenance Impacts. The constructed modifications for the Floodwall Alternative would not alter the basic maintenance guidelines for sediment and vegetation removal that should be followed for Matadero Creek upstream of Bayshore. After construction, existing maintenance access ramps will remain in place. Six existing maintenance access ramps between Highway 101 and Alma Street must be modified to provide flood protection equivalent to the tops of adjacent floodwall improvements. Raising and/or lengthening existing ramps would necessitate further in-channel modification, which this alternative seeks to minimize. Consequently, permanent flood gate structures perpendicular to the access ramps will provide necessary freeboard, in lieu of ramp modification. These barrier would be removable only by District personnel for maintenance access during non-flood conditions.

Construction Impacts. Short-term impacts during construction include noise and dust and general disturbance. Minimizing the amount of in-channel work also minimizes the amount of temporary shoring, pile driving activity, and other major sources of construction noise and disturbance. Along the east bank, where right-of-way outside of the existing floodwall is very limited, floodwall improvements may need to be constructed from within the channel.

Construction of the proposed U-frame channel section at Louis Road and the new culvert transition at Alma Street will require a temporary stream diversion around the construction sites using a cofferdam and pump system. Temporary shoring (probably with soldier piles and lagging) is necessary along both banks of the channel to facilitate channel demolition and reconstruction by retaining the sides of the excavation and limiting groundwater infiltration. The installation of this shoring can have short-term impacts in terms of noise and vibration, and could potentially result in property damage. The use of soldier piles and lagging can minimize these impacts. Prior to construction, properties should be carefully inspected and videoed for pre-existing damage. A post construction damage survey is also essential.

During construction an existing 4-inch gas line and 6-inch waterline need to be protected and/or relocated during the removal of the existing bridge structure and construction of its replacement. The existing high-voltage underground electric transmission mains, 21-inch steel casing for telephone lines, and 15-inch VCP sanitary sewer line and manholes must also be protected during construction. Temporary road closures and traffic detours will be necessary. Also, the Louis Road Bridge site is located adjacent to the newly constructed Chabad Center, which has installed a Mikvah to be used for religious ceremonies. Dust, noise, and in particular, potentially damaging vibration will be mitigated by best management practices during construction. Traffic ingress and egress will be maintained to local residents and the Center throughout construction.

Construction of requisite floodwall improvements may also require temporary traffic detours to facilitate access. Limited rights-of-way on the south channel bank may mean that temporary or permanent right-of-way acquisition is required, or more likely, that work would need to be accessed from the creek channel itself or the north bank access road. Proposed floodwall improvements are anticipated to require about 6 months for construction. Since work within the banks must be confined to a period between April 15 and October 15, multiple crews and extended work hours may be necessary to complete this work within this time window. As long as floodwall improvements proceed in parallel along both sides of the channel (to prevent unequal flooding risks on either side), work outside of the creek channel can extend beyond this construction period.

Impacts to Existing Utilities. Two existing 60kV underground high-voltage power transmission lines encased in steel conduits and surrounded by thermal sand backfill are located within the District right-of-way along the north bank of Matadero Creek. These lines are maintained by the Palo Alto Light and Power Department, enter the District's right-of-way about 600 feet above Bayshore Freeway near the City's stormwater pumping facility, and parallel the channel upstream to Alma Street. The exact location of this utility must be field-verified for any portion adjacent to construction sites. All excavations to verify trench location must be conducted by hand. This utility supplies power to the Stanford Research Park, and the consequences of service disruption would be severe and costly. Construction impact to the lines must be eliminated. Temporary or permanent relocation of this specialized utility as part of this project is cost prohibitive. At a minimum, the following protective measures must be taken:

1) The edge of any permanent structure cannot be constructed within two feet of the edge of the existing 60kV trench and thermal sand backfill.

2) The edge of any part of temporary shoring or excavations required for construction must not be within two feet of the thermal sand backfill.

3) Construction operations and methods that minimize vibrations and other potential impacts to the existing lines should be used (e.g. drilled piles in lieu of driven piles).

Geotechnical Impacts. Earthwork for this project alternative would consist of removing existing channel lining, and bridge improvements near Louis Road, and removing channel lining just downstream of Alma Street. Temporary shoring is required to excavate within the channel, although it may be possible to use the existing drilled piers at Louis Road to help with shoring. Subgrade preparation, utility protection, and the restoration of surface improvements is also required.

Groundwater is anticipated near and possibly above the invert of the existing channel, even during a typical summer construction season. Dewatering is likely needed to control groundwater and surface water so that excavations may be backfilled in a dry environment. Since the base of proposed excavations will penetrate mostly sandy clay or clayey sand, a temporary earth cofferdam could conceivably be used to divert stream flow, and the interception and removal of seepage into the excavation could be accomplished using a system of sump pits and pumps. A system of well points and/or dewatering wells may be necessary to mitigate the groundwater during construction. A layer of drain rock would be placed over a geotextile fabric to support construction vehicles.

Hazardous Materials Impacts. A Phase I Environmental Site Assessment was completed as part of this Planning Study and indicates no previous sources of soil or groundwater contamination in the vicinity of Louis Road. Previous gasoline releases at the ARCO service station located at 2995 Middlefield Road reportedly impacted soil and groundwater adjacent to the Matadero Creek channel. It appears that the remediation activities at the ARCO station have reduced contamination near the creek channel. During excavation for potential floodwall work in this vicinity for the Floodwall Alternative, residual levels of petroleum hydrocarbons may be encountered. If impacted soil is encountered, the soil should be stockpiled separately and soil samples should be collected to evaluate disposal options. (Lowney Associates, 2000)

The 60kV electrical transmission lines located within the District's right-of-way are surrounded by cooling oil within the outer steel casing. Reportedly the oil does not contain PCB, but is a mixture of Suniso 6 oil and polybutylene. These cables are 20 to 30 years old and are not secondarily contained. No leaks have been reported in the history of the cables, and a monitoring system to detect leaks is present. (Lowney Associates, 2000)

Rights-of-Way. Other than potential temporary construction easements for access or material and equipment storage, remediation elements in this reach will be constructed within existing District right-of-way. Work within public right-of-way and private property adjacent to Louis Road would be necessary to reconstruct the bridge structure as proposed.

Estimated Costs. Table 6-13 summarizes estimated construction costs for the Floodwall Alternative. Detailed cost estimates are provided in Appendix E.

Table 6-13
Estimated Costs for Reach 2 Floodwall Alternative

Project Element	*Estimated Cost*
Channel Modifications	$600,000
Bridge Replacement	$800,000
Floodwall Improvements	$3,400,000
Contingencies	$1,200,000
TOTAL COST	**$6,000,000**

Channel Alternative

To avoid or reduce the serious visual impacts of increased floodwalls, this alternative would lower water depths within the Matadero Creek channel during the base flood event. To achieve this goal, the channel would be substantially modified from Greer Road to Alma Street.

Project Description. Between Highway 101 and Greer Road, Matadero Creek has a natural bottom. Previous discussions with regulatory agencies indicate that they would generally oppose construction of a concrete structure within this reach. Therefore, the Channel Alternative examines the construction of a 36-foot wide U-frame concrete channel to replace the existing concrete lined trapezoidal channel, beginning upstream of the Greer Road bridge. A low-flow fish channel would be included, as would reconstruction of the existing maintenance access ramps. Floodwalls would be added as necessary to provide freeboard. For reasons previously discussed for the Floodwall Alternative, the Louis Road bridge would be replaced at a higher elevation.

One proposed means of increasing channel conveyance is to lower the center 20 feet of Matadero Creek and replaced this section with a rectangular U-frame channel. However, the space needed for temporary shoring required to provide a deeper excavation necessitates the removal of at least one-half of each concrete-lined channel bank. Because so much of the existing channel must be demolished, there is little anticipated savings by deepening the channel rather than widening the channel bottom and constructing vertical walls. Given potential problems with dewatering during excavation, widening the channel rather than deepening it is the preferred remediation strategy.

Hydraulic Performance. By replacing and raising the Louis Road bridge, modifying the channel from Greer Road to Alma Street, and thereby improving the downstream transition at Alma Street, Matadero Creek could discharge the design one-percent flood without overtopping. In this case, the base flood elevation would be carried below the natural bank, and floodwalls would no longer be required upstream of Middlefield Road.

Table 6-14 compares the impact on headwall elevations at each bridge crossing between the Channel Alternative and the Floodwall Alternative. Since the modification of the channel to a "U-frame" would begin upstream of Greer Road, the headwall heights at this bridge remain unchanged for the Channel Alternative. At Louis Road, the required headwall height would drop by 0.7 feet on both the upstream and downstream sides of the bridge. Beginning at Ross Road and continuing upstream, headwall improvements are completely eliminated under the Channel Alternative.

(Note in Table 6-14, that in both the Floodwall Alternative and Channel Alternative, Louis Road Bridge is raised by one foot. It is assumed that both sidewalks at this location will also be raised by one foot to elevation 9.4 feet NGVD'29.)

Table 6-15 presents a comparison of floodwall heights along the creek for the Floodwall Alternative and the Channel Alternative. For the Channel Alternative, floodwalls between West Bayshore Road and Louis Road would have to be raised to the same extent as for the Floodwall Alternative. With the modification to a "U-frame" channel, height additions to floodwalls are much lower, or non-existent, upstream of Louis Road, when compared to the Floodwall Alternative.

Table 6-14
Headwall Heights (HH) Required to meet FEMA Standards for Feasible Reach 2 Remediation Alternatives

	A: Existing			*B: Baseline Condition (Reach 1 Improvements)*		*D: Floodwall Alternative*		*Channel Alternative*	
Location	Sidewalk Elevation (ft NGVD'29)	Headwall Elevation (ft NGVD'29)	Headwall Height (feet)	WSEL (ft NGVD'29)	Headwall Height (feet)	WSEL (ft NGVD'29)	Headwall Height (feet)	WSEL (ft NGVD'29)	Headwall Height (feet)
W Bayshore Rd	9.8	10.5	0.7	5.71	0.7	5.71	0.7	5.71	0.7
D/S Greer Rd	6.2	9.3	3.1	7.90	5.7	7.90	5.7	7.90	5.7
U/S Greer Rd	6.2	10.0	3.8	8.81	6.6	8.81	6.6	8.81	6.6
D/S Louis Rd	8.4	10.6	2.2	8.83	4.4	9.26	3.9	8.57	3.2
U/S Louis Rd	8.4	11.2	2.8	12.69	8.3	10.22	4.8	9.49	4.1
D/S Ross Rd	13.2	15.5	2.3	12.90	3.7	11.21	2.3	9.82	2.3
U/S Ross Rd	13.2	15.5	2.3	14.63	5.4	12.32	3.1	9.87	2.3
D/S Middlefield Rd	16.7	19.0	2.3	14.97	2.3	14.14	2.3	12.45	2.3
U/S Middlefield Rd	16.7	19.0	2.3	16.13	3.4	14.64	2.3	12.49	2.3
D/S Cowper St	19.4	21.8	2.4	16.93	2.4	16.94	2.4	15.38	2.4
U/S Cowper St	19.4	21.8	2.4	18.25	2.4	18.28	2.4	16.43	2.4
D/S Waverley St	21.2	23.4	2.2	19.51	2.2	19.52	2.2	18.12	2.2
U/S Waverley St	21.2	23.4	2.2	20.90	3.7	20.91	3.7	18.22	2.2
Alma St	24.4	25.0	0.6	23.29	0.6	22.04	0.6	22.06	0.6
SPRR	29.5	29.6	0.1	26.53	1.0	25.05	0.1	25.05	0.1

Table 6-15
Floodwall Heights (HF) Required to meet FEMA Standards for Feasible Reach 2 Remediation Alternatives

	Range of Floodwall Heights in Feet as Measured from Lowest Adjacent Grade			
Reach	A: Existing Walls	B: Baseline Condition (Reach 1 Improvements)	D: Floodwall Alternative	Channel Alternative
W Bayshore to Greer	2 to 4	2 to 5	2 to 5	2 to 5
Greer to Louis	2 to 3	4 to 5	4 to 5	4 to 5
Louis to Ross	2 to 3	6 to 7	4 to 6	2 to 4
Ross to Middlefield	2 to 3	6 to 7	4 to 5	1 to 2
Middlefield to Cowper	1 to 2	1 to 4	1 to 2	0 to 1
Cowper to Waverley	0 to 1	2 to 3	2 to 3	0 to 1
Waverley to Bryant	1 to 2	1 to 3	1 to 3	0 to 1
Bryant to Alma	0 to 1	0 to 1	0 to 1	0 to 1
SPRR to Park	1 to 3	1 to 4	1 to 3	1 to 3
Park to Lambert	1 to 2	1 to 3	1 to 2	1 to 2
Lambert to El Camino Real	1 to 2	1 to 2	1 to 2	1 to 2

Environmental and Ecological Impacts. Construction for this alternative would also take place within the concrete-lined portion of the existing Matadero Creek channel or its right-of-way. Environmental impacts are similar to those discussed for the Floodwall Alternative, as are impacts that would result from raising Louis Road. However, to the limited extent that the channel is a habitat, impacts for channel modification are greater than for floodwall work alone.

Impacts to Local Drainage Conditions. The implementation of the Channel Alternative would improve local drainage conditions more than the Floodwall Alternative because water surface elevations in the creek channel are reduced for any given discharge, particularly between Louis Road and Alma Street.

Visual Impacts. The visual impact of headwall improvements would be identical to the Floodwall Alternative at West Bayshore Road and Greer Road Bridges. Headwall height would be reduced by 0.7 feet at Louis Road. Between Ross Road and Alma Street, headwalls and floodwalls would not have to be raised at all with this alternative.

Structural, Geotechnical, and Construction Impacts. Structural and geotechnical issues, and the construction impacts associated with this alternative have been previously discussed for the Louis Road channel modification element of the Floodwall Alternative. However, those impacts would be increased due to the 50-fold expansion in-channel work, and the need for multiple construction seasons. A far greater number of neighboring residents will be exposed to the risks of property damage due to shoring, pile driving and construction vehicle access, and for longer periods of time, than with channel work limited to Louis Road and Alma Street. The risk of damage to the 60 KV underground high-voltage power transmission lines also increases by a factor of fifty due to the increased length of channel modifications.

Maintenance Impacts. Relative to the Floodwall Alternative, maintenance costs for the Channel Alternative would be higher. By widening the channel and flattening its slope, channel velocities are reduced, thereby increasing the amount of sediment deposition that must be periodically removed. Furthermore, this alternative lowers the channel invert so that it would be below what is now the groundwater table. Stagnant water, sediment deposition, and even vegetal growth on that sediment are more likely for the Channel Alternative than the Floodwall Alternative. Consequently, the effort and cost to keep the channel clear are anticipated to be higher for the Channel Alternative.

Estimated Costs Table 6-16 summarizes estimated construction costs for the Channel Alternative. A detailed cost estimate for this alternative is provided in Appendix E.

Table 6-16
Estimated Costs for Reach 2 Channel Alternative

Project Element	*Estimated Cost*
Channel Modifications	$21,800,000
Bridge Replacement	$800,000
Floodwall Improvements	$1,400,000
Contingencies	$6,000,000
TOTAL COST	**$30,000,000**

REACH 2 PROJECT SELECTION

Table 6-17 provides a summary of the evaluations conducted for each of the feasible alternatives to provide improved flood conveyance capacity in Matadero Creek between Highway 101 and Alma Street. In Reach 2, the floodwall alternative is selected as the preferred remediation project based on a comparison of costs, impacts, community input, and effectiveness in addressing concerns. It is noted that each reach alternative meets project objectives with similar environmental impacts and maintenance implications.

The channel alternative has not been selected because its only benefit relative to the preferred plan, relatively minor ancillary improvements to the function of local drainage systems, would require a five-fold increase in capital expenditures. The channel alternative is not considered to be cost-effective.

Table 6-17
Comparative Summary of Feasible Alternatives for Matadero Creek Reach 2: Highway 101 to Alma Street

Issues and Concerns	Floodwall Alternative	Channel Alternative
1. Project Cost Estimate		
Construction	$ 6.0M	$ 30.0M
2. Physical Environment		
A. General Description	1) Replace and raise Louis Rd. Bridge and replace existing trapezoidal channel directly under the bridge with a full U-frame section to improve hydraulic performance. 2) Increase floodwall and headwall heights between Highway 101 and Waverley Street to meet FEMA standards. 3) Construct new transition at Alma Street culvert to improve hydraulic performance..	1) Replace existing trapezoidal channel from Greer Road to Alma Street with a U-frame channel to increase hydraulic capacity. 2) Replace and raise Louis Road Bridge 3) Increase floodwall and headwall heights between Highway 101 and Ross Road to meet FEMA standards.
B. Erosion	No impact.	No impact
C. Sedimentation	Sedimentation will continue to occur between Louis Road Bridge and Highway 101.	Sedimentation will continue to occur between Louis Road Bridge and Highway 101
D. Water Quality	No impact.	No impact.
E. Maintenance	Ongoing maintenance for removal of accumulated sediment between Louis Rd and Highway 101 will be required.	Ongoing maintenance for removal of accumulated sediment between Louis Rd and Highway 101 will be required.
F. Local Drainage	No significant change from current situation.	Some improvement from current situation.
3. Biological Environment		
A. Fish Habitat	Project will not affect fish habitat.	Project will not affect fish habitat.
B. Wildlife Habitat	Project will not affect wildlife habitat.	Project will not affect wildlife habitat.
4. Socio-Cultural Environment		
A. Right-of-Way	None required to complete project.	None required to complete project.
B. Aesthetics	High floodwalls and headwalls will block views of creek and foothills. (Table 6-15, 16)	Some reduction in floodwall elevations from Louis Rd. to Alma St. (Table 6-15, 16)
C. Recreation Potential	None	None

CHAPTER 7

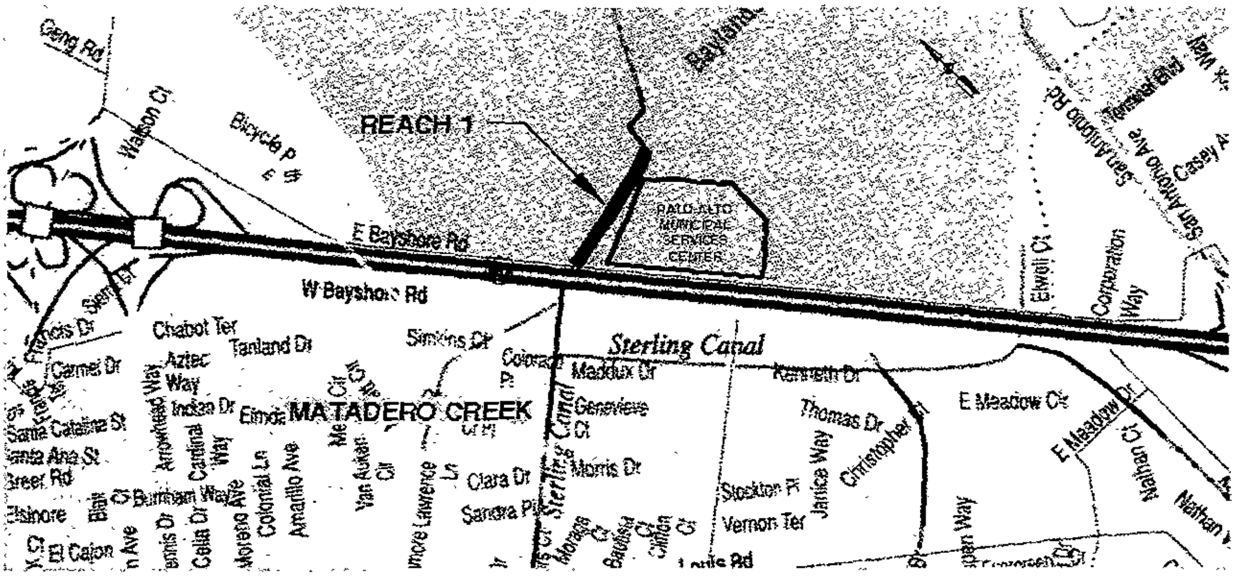
DESCRIPTION OF THE PREFERRED PROJECT

INTRODUCTION

This chapter presents a detailed reach-by-reach description of recommended capital improvements for the Matadero/Barron Creek Remediation Project. Descriptions of each project reach, adjacent land use, available right-of-way, project measures, construction procedures, impacts, and mitigation are included. The recommended plan is the combination of alternatives that were selected through an evolutionary process with the public, City staff, District staff, regulatory agencies, and environmental consultants. Recommended measures provide flood protection meeting national standards in a cost-effective manner with mitigated environmental impact. Chapter 6 explains why these project recommendations have been made. Appendix J includes "best management practices" applicable to the construction of the preferred project.

The recommended Matadero/Barron Creek Remediation Project includes:

- A nominal 60-foot wide overflow bypass from Matadero Creek downstream of Highway 101, along the City of Palo Alto Municipal Services Center, and into the Palo Alto Flood Basin.
- Channel modifications for 120 feet in the vicinity of Louis Road. The existing concrete-lined trapezoidal channel will be replaced with a rectangular concrete "U"-frame channel.
- Replacing the Louis Road Bridge with a new structure one foot higher in elevation. Ancillary roadway and local drainage improvements are also included.
- A new warped transition will be constructed on the south channel bank at the downstream face of the Alma Street / SPRR culvert. Improvements to an existing 84-inch diameter storm drain outfall at this location will be made.
- Raising existing concrete and concrete masonry floodwalls from West Bayshore Road to Alma Street to provide adequate freeboard.
- Opening both gates of the Barron Creek Diversion to allow full design diversions from the Barron Creek watershed into Matadero Creek.



REACH 1: PALO ALTO FLOOD BASIN TO HIGHWAY 101

Reach 1 extends from the Palo Alto Flood Basin upstream to the downstream face of East Bayshore Road, a frontage road for Highway 101. The creek is contained between a levee to the north and the City of Palo Alto Municipal Services Center (MSC) to the south for a distance of roughly 1,200 feet. In this reach, the creek remains channelized with a width of roughly 250 feet at the northeasterly frontage road, narrowing to a width of about 150 feet as the channel passes the northern corner of the MSC. Conditions in this reach of Matadero Creek have changed over the past thirty years. While maintenance guidelines calling for a minimum floodway width of 20 feet have been followed by clearing overhanging vegetation, sediment that has accumulated within the channel overbank area has not been removed on a consistent basis. Without regular maintenance (primarily the removal of accumulated sediment), the constricted channel and riparian vegetation seen today have been formed by natural processes occurring between the northerly levee and the MSC.

Proposed Measures

To avoid the most serious impacts to mature riparian habitat adjacent to the existing Matadero Creek channel, flood flows will be partially diverted through a high flow bypass constructed parallel to Matadero Creek and just to the north of the MSC boundary. The bypass avoids the most valuable habitat areas along the creek. The proposed bypass will occupy the 15- to 20-foot wide bank area along the MSC fence line, which is comprised primarily of a grove of non-native Eucalyptus trees and a gravel-topped levee, and will occupy part of the adjacent "jurisdictional" channel area (Figure 7-1).

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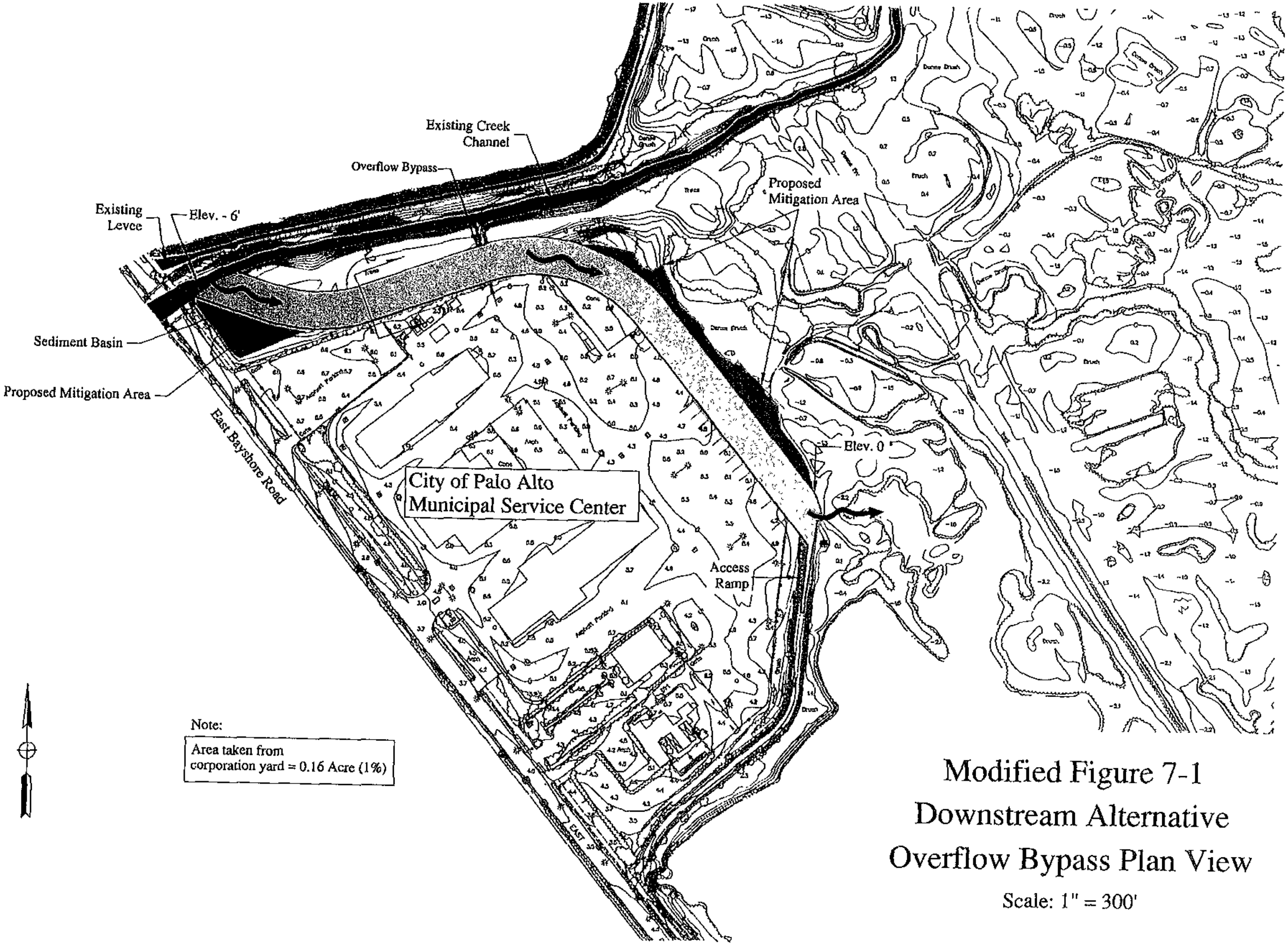


Note:

Area taken from corporation yard = 0.16 Acre (1%)

Modified Figure 7-1
Downstream Alternative
Overflow Bypass Plan View
Scale: 1" = 300'

The bypass follows a curved turn at the northern-most corner of the MSC, requiring that 0.16 acre of right-of-way be obtained from the City of Palo Also. It is proposed that the leveed area between the new bypass and PAFB be used for on-site riparian and wetland mitigation. The ground in this area will be leveled to an elevation of 0 ft. to -1 ft, and planted with appropriate riparian and wetland vegetation to blend with the existing stands of willow and other native plants.

To contain the two-year maintenance flow in the original creek channel, the proposed sediment basin access ramp will slope upward from an elevation of -6.0 feet NGVD'29 at the bridge exit to elevation +2.0 feet NGVD'29 at the bypass entrance near the MSC. Maintenance vehicles will access the sediment basin ramp along the bypass, which would continue toward the flood basin with a bottom elevation of -1.0 feet NGVD'29. The bypass invert will be approximately 1.5 feet above the flood basin's normal pool elevation to prevent standing water from remaining in the bypass over long periods of time. Figure 7-2 shows a typical section for the overflow bypass.

Since the protective levee around the MSC must be partially removed to construct the bypass, a levee or vertical wall will be built around the MSC at elevation 8.0 feet NGVD'29. This elevation provides a level of flood protection compatible with other reaches of Matadero Creek.

Construction Procedures

Within Reach 1, construction activities are limited to the days between April 15 and October 15 to minimize channel impacts. Two construction seasons are anticipated as necessary to complete the work; therefore, a construction schedule with major in-channel work completed within one season and a second season to complete access ramps, floodwalls, and site restoration is recommended.

Site Preparation. Prior to any construction activity, all project areas will be fenced with warning signs posted for public safety. Notification will be given to residents and businesses in the vicinity of the construction area. Alternate traffic and pedestrian routes around impacted areas will be posted. An 80-foot wide work area will be measured and staked from the MSC fence. Trees slated for removal and preservation will be clearly flagged. (Contract documents will specify a financial penalty for damaged jurisdictional habitat.) Work areas will be stripped of organic topsoil, which will be stockpiled for use as surface backfill. A plan for the disposal or treatment of groundwater and soil contamination will be prepared. Groundwater extracted from within about 75 feet of the fuel tank complex should be assumed to be contaminated and appropriately disposed. Approximately 5,000 cubic yards of contaminated soil will need to be excavated, stockpiled and covered with visqueen on site, and taken to a licenced landfill. (Lowney Associates, 2001)

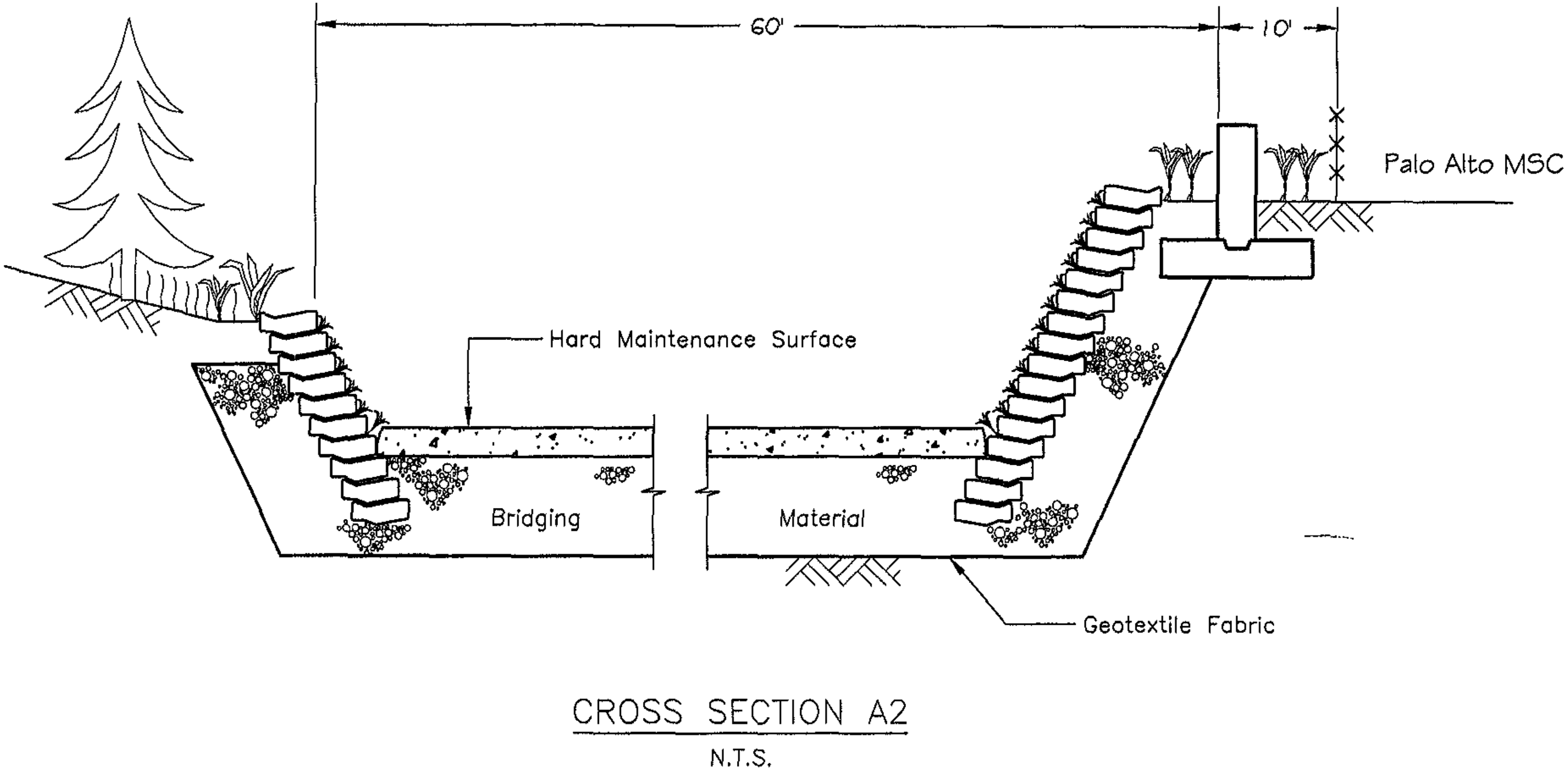


Figure 7-2
Overflow Bypass Alternative
with Gravity Retaining Wall

Excavation. The PAFB sluice gate that allows bay water to enter the basin will not be opened during the period of Reach 1 construction to minimize standing water at the project site. Sheet piling or soldier piles with lagging will be driven adjacent to the MSC fence line to retain the side of the ten-foot deep excavations. If interlocking sheet piles are not used to limit contaminated groundwater infiltration, a groundwater barrier will be placed across the lagging. A similar shoring system opposite the MSC along the riparian corridor will retain the side of the five-foot deep excavation, minimize habitat destruction, limit groundwater infiltration, and facilitate dewatering.

Excavation will typically require loaders, graders, dump trucks and other heavy equipment. A layer of drain rock overlaying geotextile stabilization fabric will be placed as a bridging material over the soft bay muds to facilitate dewatering and provide a suitable working platform for construction equipment. The contractor shall be responsible for temporary drainage within the work area at all times, and providing for any pre-existing drainage from surrounding areas.

Access to the work site will be through a temporary construction easement obtained from the City of Palo Alto through the MSC parking lot. New access gates, temporary construction ramps, and staging areas will need to be established. Intrusion into the jurisdictional corridor shall be strictly limited. Bid documents will define approved locations for equipment access and any required temporary construction easements.

Shoring and excavation will take place between May and July, which will help reduce the amount of bank erosion. The contractor will be responsible for preparing a Stormwater Pollution Prevention Plan (SWPPP) to specify measures for preventing soil erosion into the stream. California best management practices (BMP) that address this issue are summarized in Appendix J.

Bypass Construction. After bridging material has been placed as a slab underlayment, steel reinforcement for the bypass floor and vertical reinforcement that extends into the floor slab will be installed, as will weep holes or other embedded features. After inspection, concrete for the bottom slab will be poured, compacted by vibration, screed, floated, and finished with a rough texture suitable for maintenance activities. After the bottom slab has cured, precast concrete block walls or equivalent will be constructed on top of the concrete slab. Soil reinforcement in the form of a geotextile grid extending to about the existing MSC fence line will be placed between layers of free-draining permeable backfill. Once the retaining wall is finished, concrete floodwalls / vehicle barriers will be built along the MSC, with chain link fencing along the top of wall for safety. Form linings may be used for wall construction to improve aesthetics.

Site Restoration. Following the completion of bypass construction, the shoring systems will be removed, the project site cleaned up, and the area between the MSC and floodwall landscaped. (Along the MSC the shoring system may be left in place if site restoration can be accommodated.) Native grasses and shrubs will be planted within the benched concrete block wall. Identified on-site areas will be planted with riparian and wetland vegetation according to the mitigation plan. The end of the construction phase begins the mitigation monitoring phase.

Construction Impacts

A majority of the mature riparian vegetation along the main creek channel will remain undisturbed, but there will be some loss of habitat. Necessary floodwalls along the MSC boundary could limit views of the creek channel and riparian habitat from the MSC, but are not be considered to be a significant visual/aesthetic impact. During construction, soil and groundwater contaminated with petroleum hydrocarbons will be encountered from fuel storage facilities located in the northern portion of the MSC. Earthwork activities in this area will need to be performed by appropriately trained personnel. Other construction disturbances include noise and dust generation, the temporary staging of construction vehicles on the MSC property, and temporary removal of an existing fence.

Jurisdictional Areas. A total of 0.78 acre of riparian habitat will be impacted by construction in this reach. Impacted areas consist of high quality riparian habitat dominated by red willow, and non-native and ruderal habitat dominated by giant reed and sweet fennel. Impacts to wetland habitat total 0.11 acre due to the placement of fill material below Mean High Water or wetlands situated above Ordinary High Water.

Wildlife. The ruderal and eucalyptus-dominated habitat that will be removed along the edge of the MSC fence is used by several wildlife species, although it is of much lower value than the adjacent riparian and wetland vegetation. Some wetland vegetation is impacted immediately downstream of Highway 101. If the San Francisco garter snake is present along lower Matadero Creek, it is possible that the removal of this wetland vegetation could result in the loss of suitable habitat and individuals of this species.

The project will result in the loss of a small amount of breeding habitat for various bird species immediately downstream from Highway 101, near the northeast corner of the MSC, and disturb pairs nesting in vegetation adjacent to impact areas. While this is not considered a significant impact, project construction during breeding season between April and mid-August could potentially result in the direct loss of nests, eggs, and/or young of one or a few pairs, and could potentially result in the indirect loss of others through disturbance of nesting adults.

Water Quality. Oil or greasy substances, turbidity from sediment, or other materials harmful to fish that originate from the contractor's operations could enter Matadero Creek and the PAFB.

Air Quality. Construction activities will result in short-term local air quality impacts due to dust generation and vehicular exhaust. Construction and demolition activities will also raise dust and track mud onto local streets and the MSC property.

Noise. Work will result in temporary noise impacts to the MSC site, Renzel Marsh, and East Bayshore Road. Heavy equipment, jackhammers, chain saws, power tools, hammering and other construction related activity can generate relatively high noise levels adjacent to the project site. During the driving of temporary sheet piles or soldier piles, noise levels 25 feet away from the site can exceed 100 decibels. It is anticipated that freeway noise from Highway 101 will drown out the impacts of construction west of Highway 101.

Traffic Impacts. Since the work area is within the Matadero Creek channel itself, traffic impacts will result only from the access of construction vehicles onto the project site. Streets affected may include Highway 101 and East Bayshore Road, which are the primary access points. Construction must be staged so that disruption of operations at the Municipal Services Center are minimized. This facility serves as Palo Alto's emergency operations center, and it functions 24 hours per day.

Rights-of-Way. A 0.16 acre permanent easement will be purchased from the City of Palo Alto. City officials expressed a willingness to provide temporary construction easements on their property.

Mitigation Measures

The following measures will be implemented to mitigate construction impacts in Reach 1:

Jurisdictional Impacts. A total of 2.34 acres of riparian plantings will be established to mitigate project impacts to riparian habitat in this reach. Within the reach, 0.97 acre of mitigation will be provided, with the balance provided at the International School. Impacts to wetland habitats will be mitigated on-site with a total of 0.22 acre of appropriate plantings.

Wildlife. Insofar as possible, construction activities will be staged to avoid limited areas of habitat during breeding season. Work immediately downstream of Highway 101 can be delayed to the end of August to avoid the disturbance of nesting birds. The mitigation of jurisdictional impacts is also intended to compensate for the indirect loss of wildlife due to construction.

Water Quality. The contractor will prepare a SWPPP, which will identify measures to avoid increasing turbidity within Matadero Creek and the PAFB. In addition, the contractor will be required to comply with conditions outlined in the CDFG Streambed Alteration Agreement. Project construction will take place during periods of low flow, which helps limit water quality problems.

Air Quality. Earthmoving and other dust producing activities will be suspended during periods of high winds. Equipment and labor will be provided to water all exposed or disturbed surfaces if necessary, although some of the work in this reach is below mean sea level, and dust generation may not be a significant problem. However, stockpiles of soil and other materials that have been dried on-site (possibly for later disposal off-site) will be kept covered or watered. Paved construction staging areas and adjacent streets will be swept clean of mud and debris.

Noise. Local noise ordinances will be applied to the regulation of construction activities in the project specifications.

Traffic Impacts. The contractor will be directed to limit his operations to Oregon Expressway, San Antonio Road, East Bayshore Road, and Highway 101, all of which avoid residential areas.

Monitoring

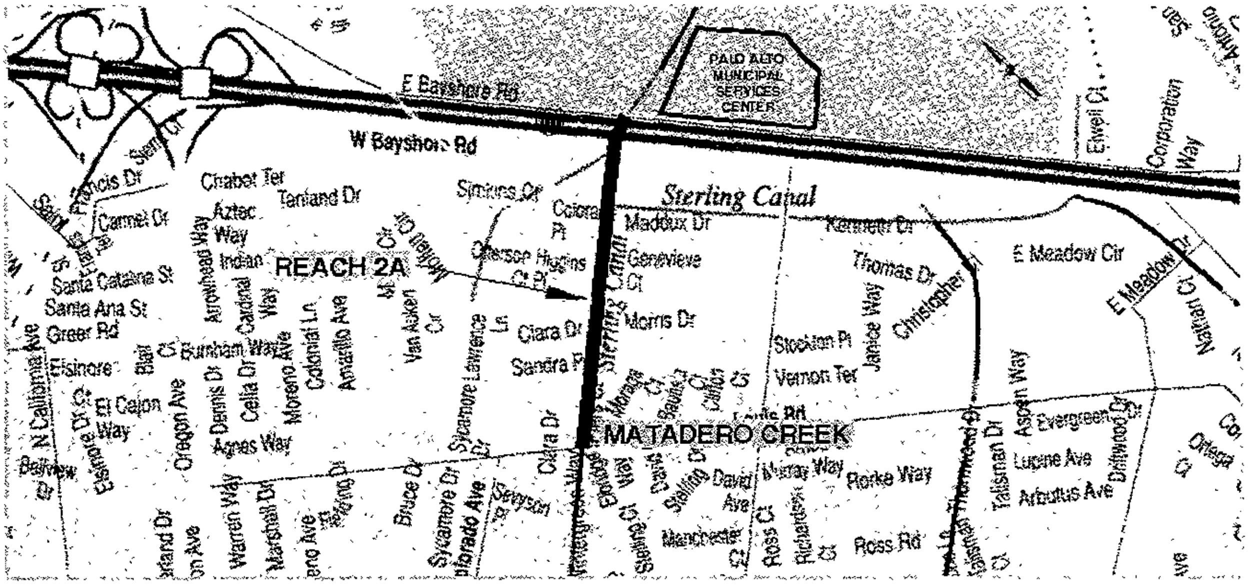
Detailed plans and specifications for mitigation will be developed by the District, whose inspectors will oversee the establishment of mitigation plans.

Reach 1 Construction Costs

Table 7-1 summarizes estimated construction costs within Reach 1. A detailed cost estimate is included in Appendix E.

Table 7-1
Estimated Costs for Reach 1

Project Element	*Estimated Cost*
Construction	$5,750,000
Mitigation Plantings	$490,000
Land Acquisition	$160,000
Contingencies	$1,600,000
TOTAL COST	**$8,000,000**



REACH 2A: HIGHWAY 101 TO LOUIS ROAD

Upstream from Highway 101, the concrete-lining beneath the bridges ends, and the channel transitions to a sacked concrete-lined slope with an earthen bottom. Emergent wetland vegetation has established itself within this reach, which is prone to the accumulation of sediments, particularly bed load. From West Bayshore Road to Greer Road, the one-percent flood is carried above the natural ground elevation to within one foot of the top of the concrete masonry unit floodwall. This channel reach provides sufficient capacity to convey the design one-percent discharge without overtopping the existing floodwalls. However, freeboard meeting District or FEMA standards is not provided. A local storm drain pumping plant discharges to Matadero Creek within this reach.

Beginning at Greer Road, flow is conveyed in a concrete-lined trapezoidal channel. Floodwalls have been built to contain floodwater and/or provide freeboard. Maintenance access ramps are provided just upstream of Highway 101 on the north and south banks, just downstream of Greer Road on the north and south banks, and just downstream from Louis Road on the north bank.

Proposed Measures

To provide freeboard meeting the objectives set forth in Chapter 2, existing floodwalls will be raised or replaced at higher elevations within this reach. Floodwalls vary by wall type, material and condition as listed in Table 7-2 below, which describes the recommended remediation. Recommended floodwall and headwall modifications, which apply to the entire Matadero Creek project area, are shown on Figures 7-3 through 7-6. The Structural Investigation Report (BCA, 2001) contains more detail for these proposed modifications.

Table 7-2
Existing Floodwalls in Reach 2A
Highway 101 to Louis Road

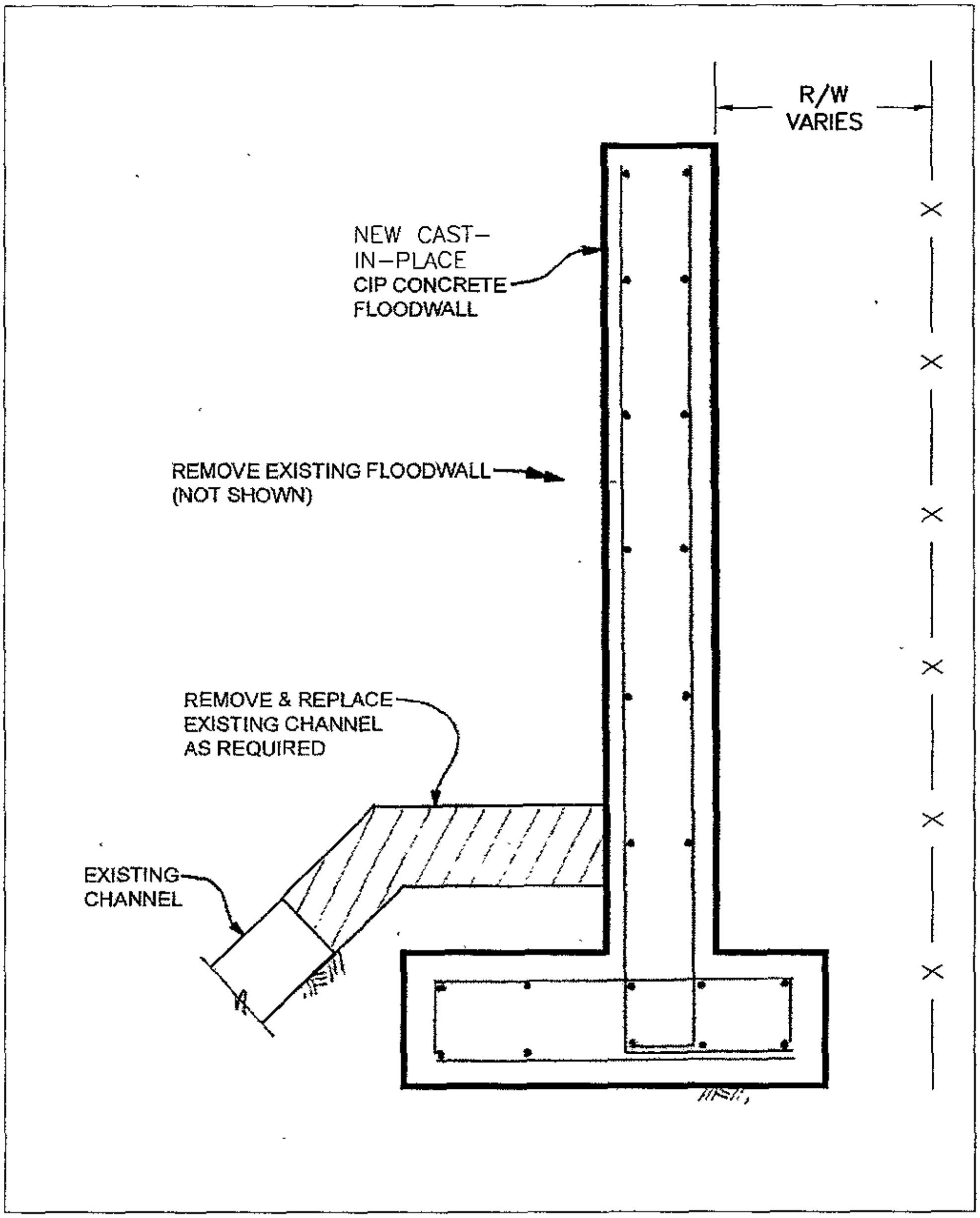
Wall Type	Description	Lineal Footage	Project Recommendation
Pre-Existing	CMU on concrete spread footing	240	Buttress or replace
Modified	CMU extensions of existing walls	1,560	Buttress or replace
Type 2	7" thick concrete wall doweled into top of existing concrete outfall structure	60	Raise floodwall
Type 3	8" thick concrete wall doweled on 2' x 2' spread footing at top of channel lining	2,400	Buttress or replace
Type 5	7" thick concrete extensions of channel lining adjacent to Greer Road bridge	150	Buttress or replace
Type 8	7" thick concrete wall extending vertically out of 7" thick sloping concrete lining	190	Buttress or replace
Total		4,600	

Source: Biggs Cardosa Associates, 2001

Upon completion of project remediation, concrete floodwall heights as measured from adjacent ground will range from three feet to five feet along the creek channel between West Bayshore Road and Louis Road. The average floodwall height through this reach is about four feet. Average and maximum heights for the existing concrete floodwall system are two feet and 3½ feet, respectively.

To complete the system of flood protection, the existing bridge headwall at Greer Road must be raised. Since the existing headwall has insufficient strength for the increased hydraulic loading imposed by raising the floodwalls and headwall, it must be strengthened or replaced.

Permanent flood control structures will also be constructed on the maintenance ramps at Highway 101 and Louis Road. The flood control walls consist of galvanized steel sill plates and end plates embedded in the concrete floodwall with sealed aluminum planks that can be removed only by District personnel when they need access to the channel during summer maintenance activities. The top elevations of these structures will match adjoining floodwall elevations, and the structures will be designed to resist full hydrostatic loading. The flood control walls will not hinder routine inspection from the top-of-bank access road. Modifications will be made to the existing fencing and the vehicular access to the City of Palo Alto's Pump Station to maintain the security and accessibility of this facility by City staff.



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Biggs Cardosa Associates, Inc.
June 2001

Figure 7-3
Floodwall Replacement

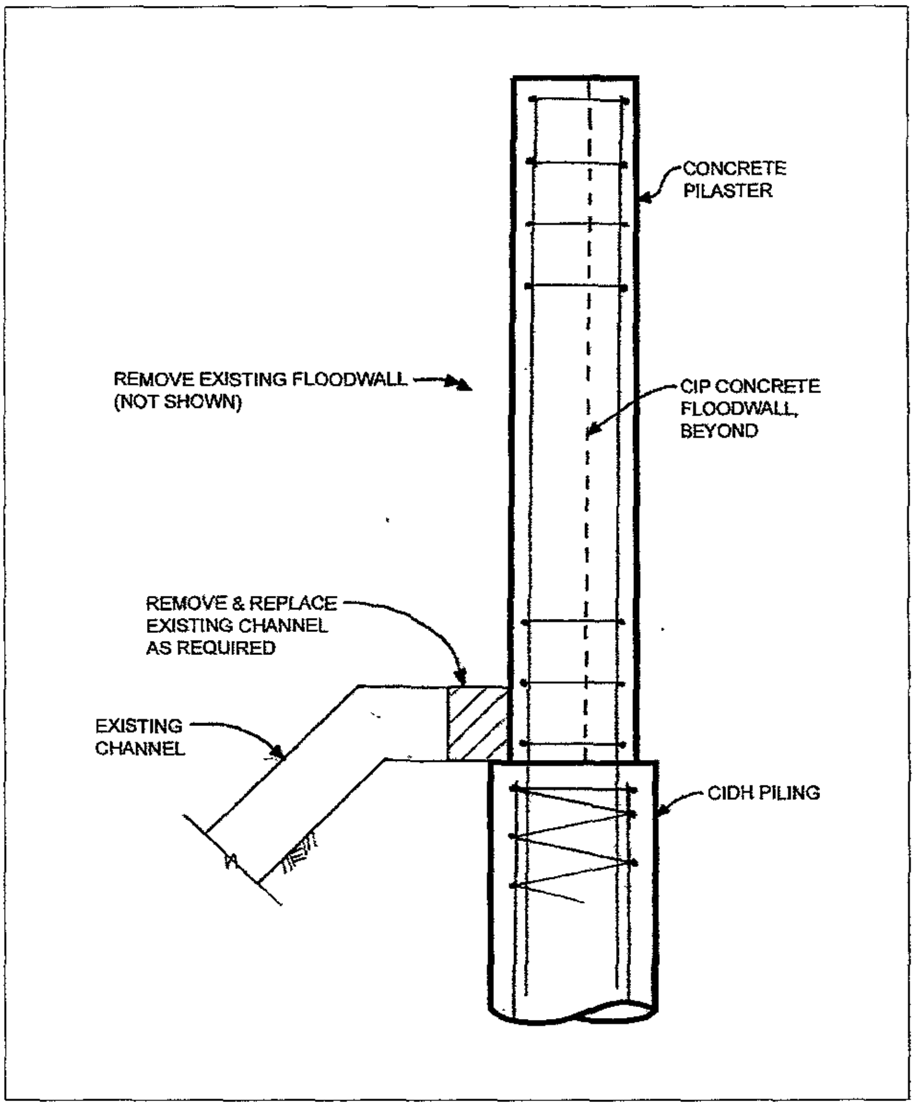
CONCRETE PILASTER
REMOVE EXISTING FLOODWALL (NOT SHOWN)
CIP CONCRETE FLOODWALL, BEYOND
REMOVE & REPLACE EXISTING CHANNEL AS REQUIRED
EXISTING CHANNEL
CIDH PILING

Figure 7-4
Floodwall Replacement
for Low Clearance Applications

Biggs Cardosa Associates Inc.
June 2001

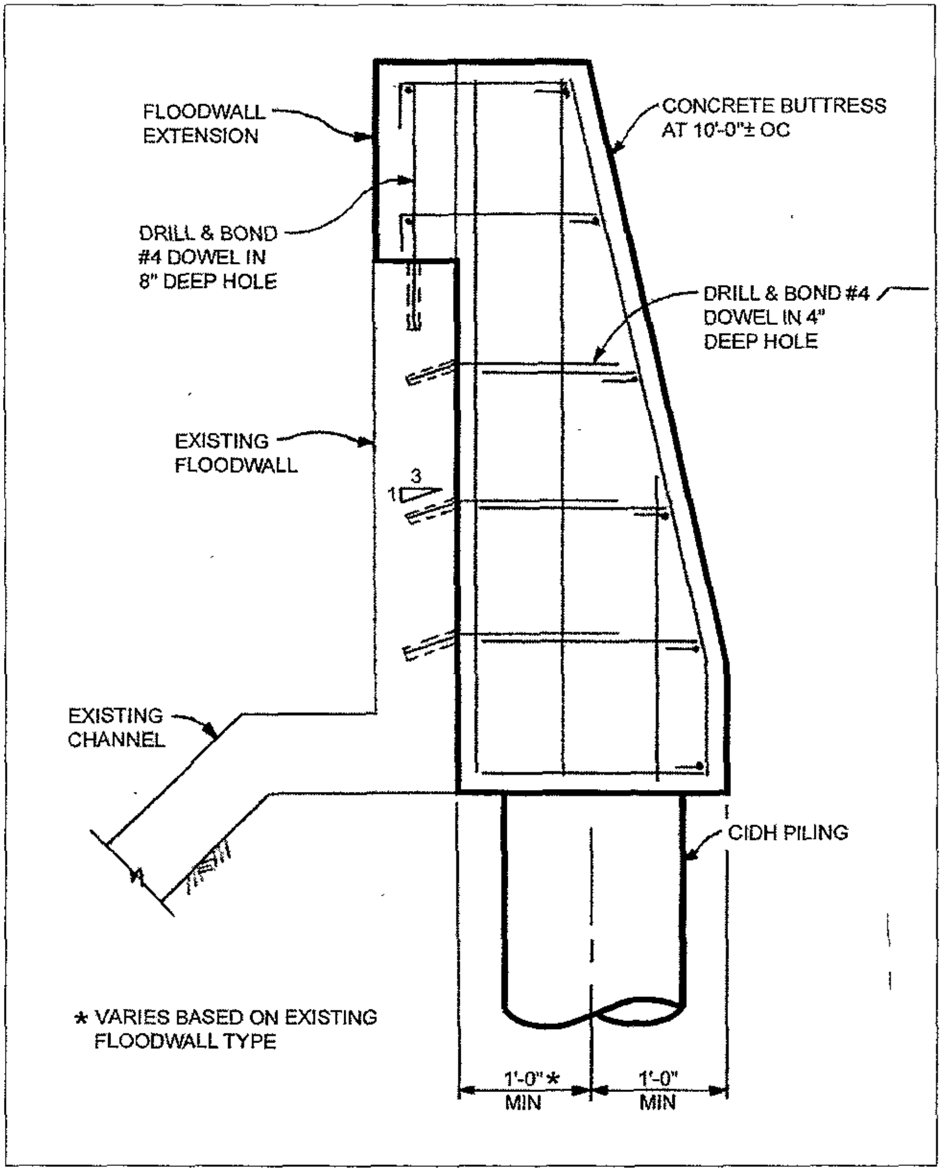
FLOODWALL EXTENSION
CONCRETE BUTTRESS AT 10'-0"± OC
DRILL & BOND #4 DOWEL IN 8" DEEP HOLE
DRILL & BOND #4 DOWEL IN 4" DEEP HOLE
EXISTING FLOODWALL
3
1
EXISTING CHANNEL
CIDH PILING
* VARIES BASED ON EXISTING FLOODWALL TYPE
1'-0" * MIN
1'-0" MIN

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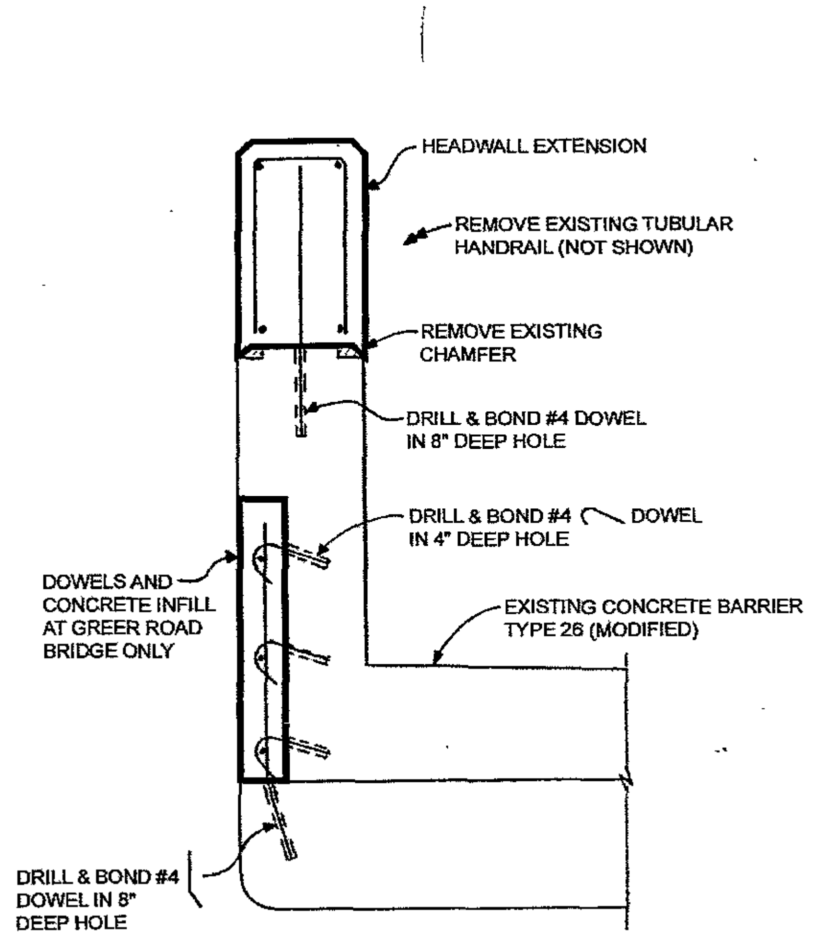
Figure 7-5
Floodwall Buttress

Biggs Cardosa Associates, Inc.
June 2001


HEADWALL EXTENSION
REMOVE EXISTING TUBULAR HANDRAIL (NOT SHOWN)
REMOVE EXISTING CHAMFER
DRILL & BOND #4 DOWEL IN 8" DEEP HOLE
DRILL & BOND #4 DOWEL IN 4" DEEP HOLE
DOWELS AND CONCRETE INFILL AT GREER ROAD BRIDGE ONLY
EXISTING CONCRETE BARRIER TYPE 26 (MODIFIED)
DRILL & BOND #4 DOWEL IN 8" DEEP HOLE

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Biggs Cardosa Associates, Inc.
June 2001

Figure 7-6
Profile of Typical Headwall Extension

Construction Procedures

Proposed floodwall and headwall improvements within Reach 2A and Reach 2C (described later in this chapter), are anticipated to require approximately six months to complete. All work within or affecting the creek channel must be confined to the period between April 15 and October 15. As a result, multiple crews and extended work hours may be required to complete the work within the allotted window of opportunity. However, if some of the floodwall or headwall work does not affect the creek channel or require equipment to be within the creek channel, the work can extend beyond the stated construction period.

Floodwall improvements must be completed so that work on the north bank proceeds in tandem with work on the south bank, to prevent one side from being at increased flood risk relative to the other side prior to project completion.

Site Preparation. Prior to any construction activity, all project areas will be fenced with warning signs posted for public safety. Notification will be given to residents and businesses in the vicinity of the construction area. Alternate traffic and pedestrian routes around impacted areas will be posted. Construction storage and staging areas will be identified and fenced for security.

Floodwall Construction. Access to the work sites will be District rights-of-way, either on the gravel maintenance access roads adjacent to the channel bank, or through the channel itself. The contractor will not be allowed to trespass on private property to complete his work. Floodwall improvements include raising, strengthening (buttressing), or replacing floodwalls as tabulated, illustrated, and described herein. Raised floodwall segments will consist of cast-in-place concrete wall extensions constructed directly on top of and doweled in to the existing Type 8 floodwalls. Three other options are available to replace or strengthen wall segments:

1) Replace the existing floodwall with a cast-in-place concrete wall on spread footings along the same alignment, similar to existing Type 6 floodwalls. This option should require only minor removal and replacement of the existing channel alignment (Figure 7-3).

2) Replace the existing floodwall with a cast-in-place concrete wall spanning horizontally between concrete pilaster extensions of cast-in-drilled-hole (CIDH) piling. This option is more expensive than the other two, but may prove suitable for locations where there is little construction clearance to the existing right-of-way or other obstructions (60 kV line, other utilities, etc.). This option is shown on Figure 7-4.

3) Strengthen the existing floodwall by buttressing the wall with pilaster extensions of CIDH piling. This option requires about two feet of space behind the existing wall, and would thus encroach on the maintenance access road or other District right-of-way. Figure 7-5 details this floodwall option.

Bridge Headwall Modification. At the Greer Road Bridge, the existing headwall is insufficient to withstand hydraulic loading with water at the top of the proposed raised wall. Raising and strengthening this headwall will include the following items:

- remove existing tubular hand railing
- dowel into the existing reinforced concrete bridge deck slab
- dowel into the face of the existing headwall
- pour a thickened base at the existing headwall
- pour a cast-in-place concrete wall extension

Site Restoration. Following the completion of floodwall construction, all construction debris and equipment will be removed from the project site, staging and storage areas, and all public streets and District rights-of-way.

Construction Impacts

Short-term impacts during construction include noise and dust and general disturbance to neighboring residential areas. Construction of requisite floodwall improvements may also require temporary traffic detours to facilitate access. Limited rights-of-way on the south channel bank may require temporary or permanent right-of-way acquisition, or, more likely, that access will have to be achieved from the creek channel itself or the north bank access road.

Jurisdictional Areas. No jurisdictional areas are impacted by remedial work within Reach 2A.

Wildlife. Emergent wetlands between Greer Road and Highway 101 support a number of waterfowl and other birds. Floodwall construction is not expected to directly impact the wetlands in this reach, but general construction activities on the adjacent banks may disturb the ducks. This is not considered to be a significant impact given the project's proximity to urban areas, the freeway, and an electrical substation.

Water Quality. Oil or greasy substances, turbidity from sediment, or other materials harmful to fish that originate from the contractor's operations could enter Matadero Creek and eventually the Palo Alto Flood Basin.

Air Quality. Construction activities will result in short-term local air quality impacts due to dust generation and vehicular exhaust. Construction and demolition activities will also raise dust and track mud onto local streets and neighboring properties.

Noise. Work will result in temporary noise impacts to the PG&E substation, City of Palo Alto stormwater pumping plant, and residents who live along the creek right-of-way. Heavy equipment, jackhammers, chain saws, power tools, hammering and other construction related activity can generate relatively high noise levels adjacent to the project site. To meet an accelerated project schedule, extended working hours may be necessary. This would increase the level of noise impact, particularly when residents are home from work on weekdays, as well as weekends.

Traffic Impacts. The need for construction access will impact local traffic circulation patterns, since there are a limited number of access points. Louis Road in particular may experience rather heavy truck traffic during construction.

Impacts to Public Utilities. Two existing 60kV underground high-voltage power transmission lines encased in steel conduits and surrounded by thermal sand backfill are located within the District right-of-way along the north bank of Matadero Creek. These lines are maintained by the Palo Alto Light and Power Department, enter the District's right-of-way about 600 feet above Bayshore Freeway near the City's stormwater pumping facility, and parallel the channel upstream to Alma Street. This utility supplies power to the Stanford Research Park, and the consequences of service disruption would be severe and costly. Near the electrical substation, high voltage overhead lines cross perpendicular to the creek.

Visual Impacts. Floodwall elevations would be increased by an average of two feet in Reach 2A to meet FEMA freeboard criteria.

Mitigation Measures

The following measures will be implemented to mitigate construction impacts in Reach 2A:

Wildlife. Insofar as possible, construction activities will be carried out to avoid disturbances to ducks and other birds living within the District's right-of-way.

Water Quality. The contractor will prepare a SWPPP and be required to comply with conditions outlined in the CDFG Streambed Alteration Agreement, necessary only for the earth bottom reach between Highway 101 and Greer Road. Project construction will occur during periods of low flow.

Air Quality. Earthmoving and other dust producing activities will be suspended during periods of high winds. Equipment and labor will be provided to water all exposed or disturbed surfaces if necessary, although some of the work in this reach is below mean sea level, and dust generation may not be a significant problem. However, stockpiles of soil and other materials that have been dried on-site (possibly for later disposal off-site) will be kept covered or watered. Paved construction staging areas and adjacent streets will be swept clean of mud and debris.

Noise. Local noise ordinances will be applied to the regulation of construction activities in the project specifications.

Traffic Impacts. The contractor will be directed to prepare a traffic detour plan and limit his routes to pre-determined streets and access points, as discussed at the preconstruction conference.

Impacts to Public Utilities. The exact location of the existing 60kV power transmission lines will be field-verified for any portion adjacent to construction sites. All excavations to verify trench location must be conducted by hand. Protective measures include:

1) The edge of any permanent structure cannot be constructed within two feet of the edge of the existing 60kV trench and thermal sand backfill.

2) ~~The~~ edge of any part of temporary shoring or excavations required for construction must not be within two feet of the thermal sand backfill.

3) Construction operations and methods that minimize vibrations and other potential impacts to the existing lines should be used (e.g. drilled piles in lieu of driven piles).

Visual Impacts. On June 18, 2002 FEMA approved an analytical procedure known as the "risk-based approach" to partially mitigate increased floodwall elevations. The procedure is presented in Appendix I. Essentially, statistical analyses are used to establish floodwall elevations in lieu of arbitrary freeboard requirements. The risk-based approach is used from West Bayshore Road to Ross Road, which coincides with the area of tidal inundation. Upstream of Ross Road, improved floodwalls will comply with NFIP regulations.

Where the risk-based approach has been applied, floodwall elevations are lower than those presented in Chapter 6, and the distinction between bridge headwalls and adjacent channel floodwalls no longer applies. Table 7-3 presents headwall heights required to meet FEMA-approved freeboard based on the risk-based approach for the preferred project in Reach 2A.

Table 7-3
Headwall Heights (HH) Required
to meet FEMA-Approved "Risk-Based" Freeboard in Reach 2A

Location	Existing			Proposed	
	Sidewalk Elevation (ft NGVD'29)	Headwall Elevation (ft NGVD'29)	Headwall Height (feet)	Headwall Elevation (ft NGVD'29)	Headwall Height (feet)
W Bayshore Rd	9.8	10.5	0.7	10.5	0.7
D/S Greer Rd	6.2	9.3	3.1	10.0	3.8
U/S Greer Rd	6.2	10.0	3.8	11.2	5.0
D/S Louis Rd[1]	8.4	10.6	2.2	11.5	2.2

[1] Louis Road is to be raised one foot with a new sidewalk at elevation 9.4 feet NGVD'29, and the existing headwall height of 2.2 feet will be maintained as a minimum.

The highest required headwall in this reach is 5.0 feet above the sidewalk at the upstream face of Greer Road Bridge. Further visual mitigation will be achieved through the use of architectural treatment to floodwalls and bridge headwalls. Other mitigation measures may include reconfigured sidewalks to further reduce the effective wall height, and the use of removable barriers at bridge headwalls similar to the barriers proposed for maintenance ramps.

Table 7-4 presents the required floodwall heights along Matadero Creek between West Bayshore Road and Louis Road to meet FEMA-approved risk-based requirements.

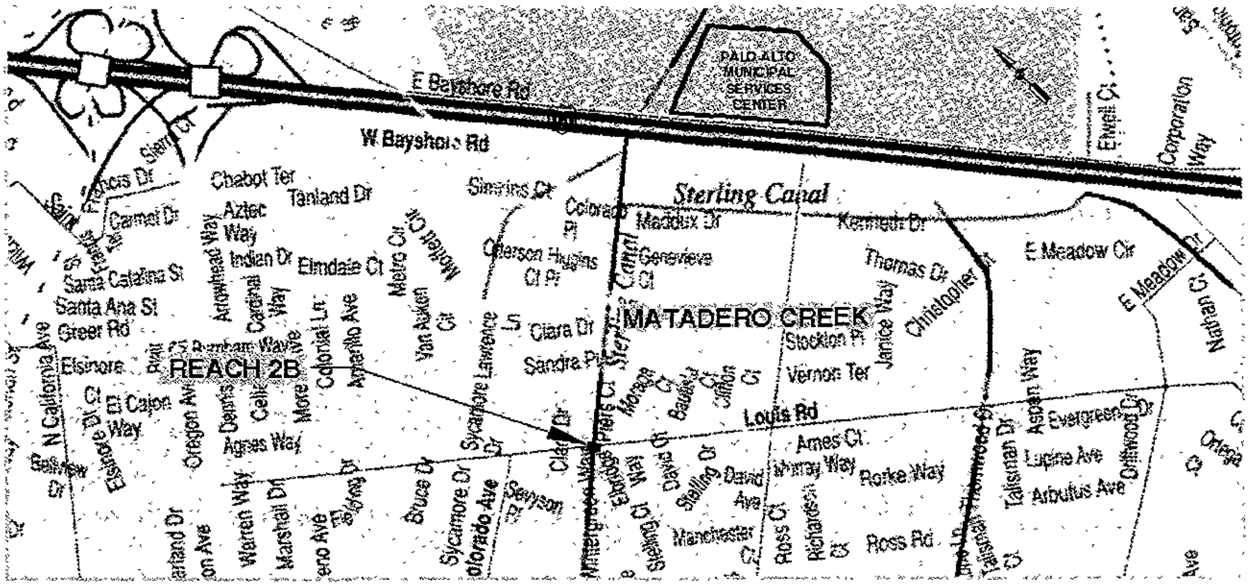
Table 7-4
Floodwall Heights (HF) Required to meet FEMA-Approved "Risk-Based" Freeboard in Reach 2A
(As Measured from Lowest Adjacent Grade in Feet)

Reach	*Existing Walls*	*Proposed Improvements*
W Bayshore Rd to Greer Rd	2 to 4	3 to 5
Greer Rd to Louis Rd	2 to 3	3 to 4

Since proposed floodwall heights in this reach are less than six feet as measured from lowest adjacent grade, significant visual impacts are essentially mitigated. Six feet is the height of typical privacy fences in residential areas.

Reach 2A Construction Costs

Project work in Reach 2A is estimated to cost $1.8 million (Appendix E).



REACH 2B: LOUIS ROAD

At the Louis Road bridge, there is insufficient capacity to pass the design one-percent flow without causing the floodwalls to be overtopped upstream if any flow is diverted from Barron Creek. This location is projected as the first break-out point on Matadero Creek. Without diversions, the water surface is carried two feet above natural grade, and available freeboard is less than one foot just upstream of Louis Road. This reach is also subject to tidal flooding, but is at an even greater risk of overtopping during freshwater flooding events. The Louis Road Bridge is pressurized under design flood conditions.

Proposed Measures

To improve hydraulic performance at the Louis Road bridge, the existing trapezoidal channel directly under the bridge will be replaced with a full U-frame channel section along the same alignment. The U-frame channel will be 36 feet wide to match the existing floodwall-to-floodwall width. A 40-foot long transition from trapezoidal shape to rectangular shape will be provided upstream of the bridge and a 20-foot long transition from rectangular-to-trapezoidal shape will be constructed on the downstream side. Channel modifications adjacent to the bridge also include the replacement of any existing floodwalls impacted by construction and necessary modifications to the existing maintenance access ramp on the downstream side of Louis Road. Figure 7-7 shows the proposed project improvements in this reach.

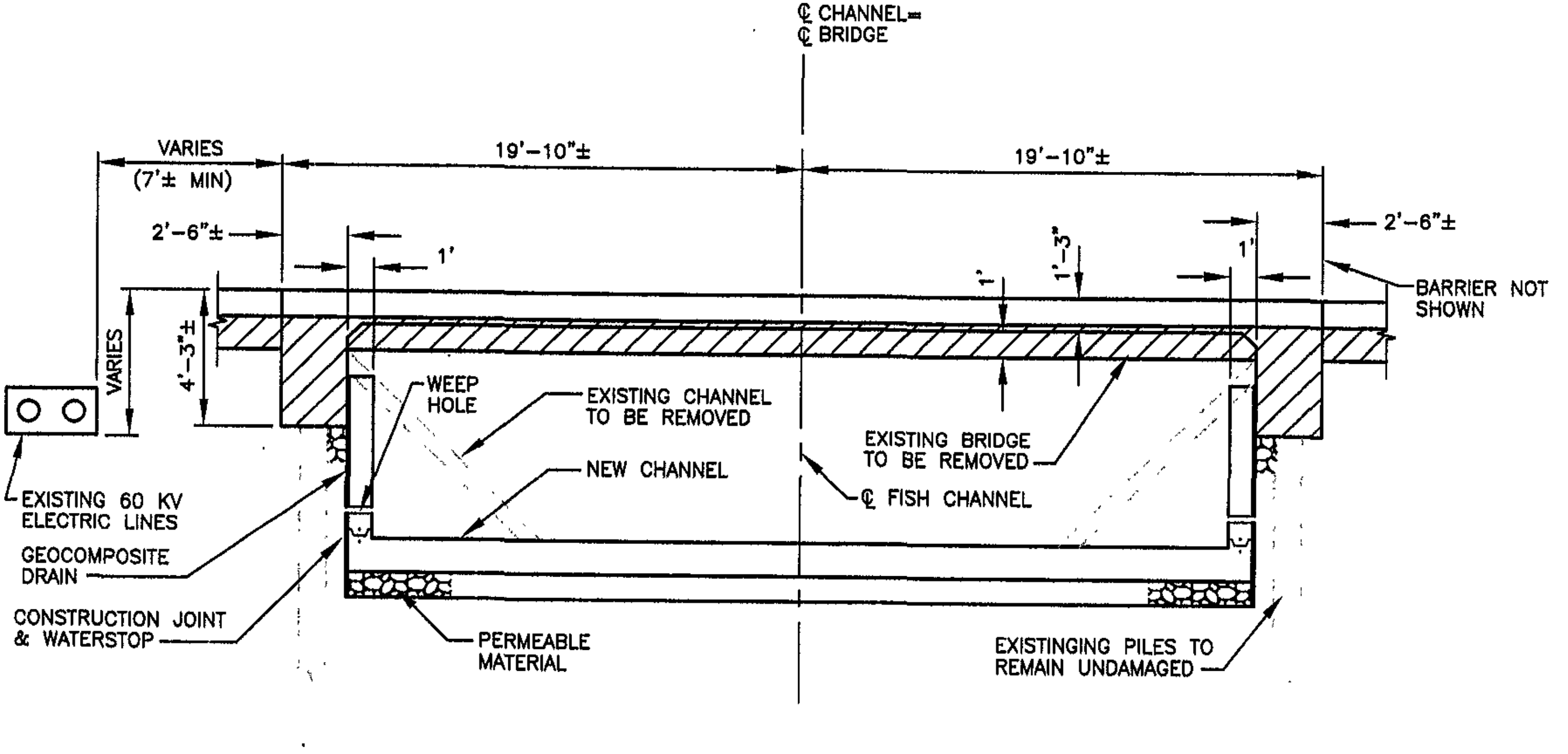


FIGURE 7–7
LOUIS ROAD BRIDGE REPLACEMENT

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The Louis Road bridge is not sufficiently reinforced to safely handle hydrostatic loading during the design event. There is also be the opportunity to improve bridge hydraulics at the same time. Field surveys indicate that Louis Road may be raised vertically by about one foot at Matadero Creek and remain within design standards for roadway sight distance and drainage.

Louis Road is classified by the City of Palo Alto as a collector street. For this level of service in a highly developed area on ordinary terrain (35 mph design speed), maximum recommended street grade is four percent with a minimum horizontal sight distance of 250 feet. To raise Louis Road by one foot at the creek crossing, a 200-foot long vertical curve with a 1.9 percent approach from the north beginning at Piers Court, and a 2.6 percent approach from the south beginning at Clara Drive could be feasible. Under this preliminary design, the calculated sight distance is 255 feet.

Chabad Center's driveway and three private driveways accessed from Louis Road between Piers Court and Clara Drive will be regraded to match the new Louis Road profile. All private driveways will have positive drainage to the street, although the driveway south of the bridge will fall toward the street at less than one-percent grade.

Construction Procedures

Proposed channel and bridge improvements in Reach 2B are anticipated to require approximately six months to complete the major structural components of channel modifications, bridge removal and bridge replacement. Another one or two months will be required to complete associated roadway approach work. All work within or affecting the creek channel must be confined to the period between April 15 and October 15. Roadway and ancillary work that does not affect the channel can occur outside of this window.

To accomplish this work within a single six-month channel construction season, closing Louis Road to through traffic at Matadero Creek is recommended. The local street network is sufficiently robust to accommodate additional traffic for a relatively short period of time.

Site Preparation. Prior to any construction activity, Louis Road will be closed to all but local and construction traffic between Piers Court and Clara Drive. All project areas will be fenced with warning signs posted for public safety. Notification will be given to residents and businesses in the vicinity of the construction area. Alternate traffic and pedestrian routes around impacted areas will be posted. Construction storage and staging areas will be identified and fenced for security.

Channel Modification. Directly under the bridge superstructure, the existing concrete lined trapezoidal channel will be replaced with a full width U-frame section along the same alignment. Upstream and downstream warped wall transitions will be provided for proper hydraulic performance. Channel modifications adjacent to the bridge will also incorporate the extension of floodwalls necessary for freeboard. Special detailing and design will be required at the maintenance access ramp. Construction of the modified channel section entails:

- Building a temporary stream diversion around the construction zone using a cofferdam and pump system.
- Installing temporary shoring along both channel banks, with a soldier pile and lagging system preferred, to retain the sides of the 13-foot deep excavation, limit groundwater infiltration, and facilitate dewatering during construction.
- Demolishing the existing concrete channel lining, with saw cut joints at the project limits.
- Placing drain rock as a bridging material overlaying geotextile stabilization fabric along the channel invert to facilitate dewatering and to provide a suitable working platform for construction equipment.
- Placing steel reinforcement and pouring the bottom slab.
- Forming and pouring vertical concrete channel walls and floodwall extensions cantilevered from the invert slab. Walls will be backfilled with permeable material prior to the removal of temporary shoring.
- Removing temporary shoring and the stream diversion.

Bridge Construction. The existing Louis Road bridge is anticipated to be replaced in kind using a new prestressed concrete slab with integral diaphragm abutments supported on piles (Biggs Cardosa, 2001). Bridge replacement is proposed to occur on the same alignment and structural footprint as the existing structure. This alignment allows for the reuse of the existing Class 45C driven piles, subject to a final geotechnical review. If the existing piles cannot be reused, then drilled-in-place piers are recommended.

Roadway Work. After the bridge superstructure is completed, pavement on both bridge approaches will be pulverized and removed. Base material will be over-excavated as required by roadway design. Residential driveways will be saw cut as required and removed. The subgrade at each driveway will be excavated as needed to provide final grade. Concrete curbs, gutters, and driveways will then be poured. Finally, aggregate base will be placed and compacted to grade on Louis Road, which will then be paved, striped, and reopened to through traffic.

Construction Impacts

Short-term impacts during construction include noise and dust and general disturbance to neighboring residential areas. The project limits abut both front and back yards. Temporary shoring and pile driving activities are other major sources of construction noise and disturbance. Along the east bank, where right-of-way outside of the existing floodwall is very limited, most of the channel improvements may be constructed from within the channel itself.

Jurisdictional Areas. No jurisdictional areas are impacted by remedial work within Reach 2B.

Wildlife. Although the channel sometimes has standing water in the vicinity of Louis Road, it is concrete-lined and wildlife impacts are not significant.

Water Quality. Oil or greasy substances, turbidity from sediment, or other materials harmful to fish that originate from the contractor's operations could enter Matadero Creek and eventually the Palo Alto Flood Basin.

Air Quality. Construction activities will result in short-term local air quality impacts due to dust generation and vehicular exhaust. Construction and demolition activities will also raise dust and track mud onto local streets and neighboring properties.

Noise. Work will result in temporary noise impacts to the residents who live along the creek right-of-way. Heavy equipment, jackhammers, chain saws, power tools, hammering and other construction related activity can generate relatively high noise levels adjacent to the project site. To meet an accelerated project schedule, extended working hours may be necessary. This would increase the level of noise impact, particularly when residents are home from work on weekdays, as well as during weekends.

Property Damage. The installation of shoring produces vibrations that could potentially result in property damage. The bridge site is located adjacent to the newly constructed Chabad Center, which installed a Mikvah to be used for religious ceremonies. Dust, noise, and in particular, potentially damaging vibration must be mitigated during construction. Prior to construction, properties should be carefully inspected and videoed for pre-existing damage.

Traffic Impacts. Temporary road closures and traffic detours would be necessary during the replacement of the Louis Road bridge, which is expected to last up to six months. Vehicular and pedestrian traffic would likely be routed to Greer Road and Ross Road via Loma Verde Avenue and Colorado Avenue. Once the bridge is reopened, however, vehicular and pedestrian traffic should return to existing patterns.

Impacts to Local Drainage Conditions. The issue of preserving local site drainage characteristics is of great concern. Changes in a road profile that worsen "nuisance" ponding are not acceptable. Using topographic information from a limited 1999 site survey, it appears that increasing the grade along Louis Road from Piers Court north to Clara Drive by up to one foot would not significantly alter the site drainage at any affected properties. The safe overland release elevation for each property would not be changed to the point where the potential for flooding on-site during lesser events would be increased. Chabad Center has a drainage release along its southerly property, which would not be affected by the proposed Louis Road grade changes.

Similarly, the residence located across the street from Chabad Center would continue to positively drain to Louis Road. To the north, properties can still release to Clara Drive. During final design, additional surveys will be required to confirm the continued safe release of site drainage, and to establish whether additional storm drainage systems are required on individual properties to prevent nuisance runoff from being trapped in garages or other areas.

Impacts to Public Utilities. Impacts to the 60kV underground high-voltage power transmission lines have been previously described. In addition, an existing 4-inch gas line and 6-inch waterline need to be protected and/or relocated during the removal of the existing bridge structure and construction of its replacement. The existing high-voltage underground electric transmission mains, 21-inch steel casing for telephone lines, and 15-inch VCP sanitary sewer line and manholes must also be protected during construction. Temporary road closures and traffic detours will be necessary.

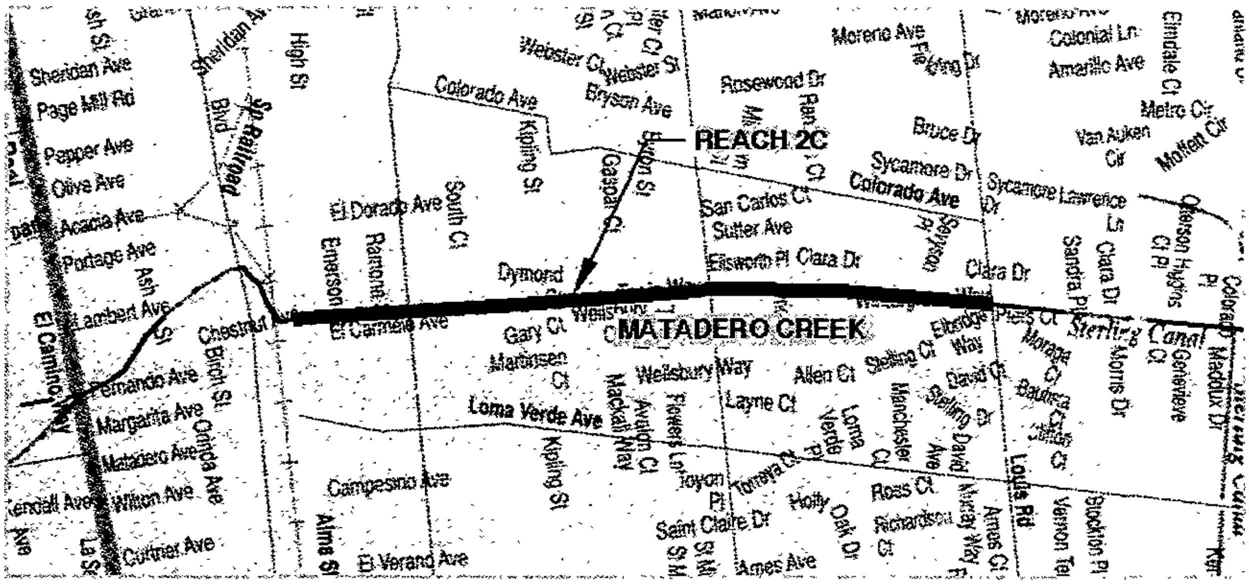
Mitigation Measures

The following measures, in addition to those listed for Reach 2A, will be implemented to mitigate project impacts in Reach 2B:

Traffic Impacts. The District will prepare a traffic detour plan, present it to the public, and specify traffic control requirements for the contractor. Traffic ingress and egress will be maintained to local residents and the Chabad Center throughout construction.

Reach 2B Construction Costs

Project work in Reach 2B is estimated to cost $1.5 million as detailed in Appendix E. The anticipated cost to replace the Louis Road bridge is $300,000. Roadway work, traffic control, utility protection, and work on adjacent properties is expected to total $700,000 in cost. Channel modifications should cost $500,000, which is equivalent to about $4,000 per lineal foot.



REACH 2C: LOUIS ROAD TO ALMA STREET

Reach 2C is entirely comprised of concrete-lined trapezoidal channel on steeper slopes that limit the amount of sediment accumulation. Upstream from Ross Road, the channel provides sufficient capacity to convey the design one-percent discharge without overtopping the existing floodwalls, but freeboard meeting District or FEMA standards is not provided. Local storm drains discharge by gravity through flapgates into Matadero Creek within this reach. A maintenance access ramp is provided just downstream of Middlefield Road on the south bank

Proposed Measures

To provide freeboard meeting the objectives set forth in Chapter 2, existing floodwalls will be raised or replaced at higher elevations within this reach. Floodwalls vary by wall type, material and condition as presented in Table 7-5, with recommended remediation. Recommended floodwall modifications, which apply to the entire Matadero Creek project area, were shown earlier in this chapter in Figures 7-3 through 7-6. The Structural Investigation Report (BCA, 2001) contains more detail on these proposed modifications. (Floodwall footage includes both sides of the creek.)

A new warped concrete transition will be provided on the south side of the channel at the Alma Street culvert exit. The existing 84-inch diameter RCP storm drain will be extended through the transition, with a formed outfall that matches the warped shape.

Table 7-5
Existing Floodwalls in Reach 2C
Louis Road to Alma Street

Wall Type	*Description*	*Lineal Footage*	*Project Recommendation*
Type 3	8" thick concrete wall doweled on 2' x 2' spread footing at top of channel lining	3,910	Buttress or replace
Type 6	9½" thick concrete wall on 1' by 3'-9½" spread footing buried below top of channel lining	300	Raise floodwall
		150	No modification
Type 7	9½" thick concrete wall on 1' by 2'-3½" spread footing buried below top of channel lining	3,080	Raise floodwall
		1,250	No modification
Type 8	7" thick concrete wall extending vertically out of 7" thick sloping concrete lining	120	Raise floodwall
		1,630	Buttress or replace
		50	No modification
Total		9,040	(Wall Modifications)

Source: Biggs Cardosa Associates, 2001

As indicated for Reach 2A, the risk-based approach to establish floodwall elevations is used from West Bayshore Road to Ross Road, and floodwall improvements upstream of Ross Road will comply with NFIP regulations. The upstream face of the Waverley Street Bridge is the only location between Ross Road and Alma Street where FEMA freeboard applies. In this case, applying the risk-based approach actually results in a slightly higher floodwall (Appendix I). Table 7-6 presents headwall heights required to meet FEMA-approved freeboard for the preferred project in Reach 2C.

The headwall height at the upstream face of Louis Road Bridge is the highest revised headwall in this reach. Visual mitigation for this increase may possibly be achieved with a reconfigured sidewalk or through the use of architectural treatment to the bridge headwall.

Table 7-6
Headwall Heights (HH) Required to meet FEMA-Approved "Risk-Based" Freeboard in Reach 2C

	Existing			*Proposed*	
Location	***Sidewalk Elevation (ft NGVD'29)***	***Headwall Elevation (ft NGVD'29)***	***Headwall Height (feet)***	***Headwall Elevation (ft NGVD'29)***	***Headwall Height (feet)***
U/S Louis Rd[1]	8.4	11.2	2.8	13.7	4.3
D/S Ross Rd	13.2	15.5	2.3	15.5	2.3
U/S Ross Rd	13.2	15.5	2.3	16.3	3.1
D/S Middlefield Rd	16.7	19.0	2.3	19.0	2.3
U/S Middlefield Rd	16.7	19.0	2.3	19.0	2.3
D/S Cowper St	19.4	21.8	2.4	21.8	2.4
U/S Cowper St	19.4	21.8	2.4	22.0	2.6
D/S Waverley St	21.2	23.4	2.2	23.4	2.2
U/S Waverley St	21.2	23.4	2.2	25.0	3.8
D/S Alma St	24.4	25.0	0.6	25.0	0.6

[1] Louis Road is to be raised one foot with a new sidewalk at elevation 9.4 feet NGVD'29.

Table 7-7 presents required floodwall heights along Matadero Creek between Louis Road and Ross Road that are determined using FEMA-approved risk-based requirements, and from Ross Road to the SPRR, determined using standard FEMA freeboard criteria.

Table 7-7
Floodwall Heights (HF) Required to meet FEMA-Approved "Risk-Based" Freeboard in Reach 2C
(As Measured from Lowest Adjacent Grade in Feet)

Reach	*Existing Walls*	*Proposed Improvements*
Louis Rd to Ross Rd	2 to 3	3 to 5
Ross Rd to Middlefield Rd	2 to 3	3 to 4
Middlefield Rd to Cowper St	1 to 2	1 to 3
Cowper St to Waverley St	0 to 1	2 to 3
Waverley St to Bryant St	1 to 2	1 to 3
Bryant St to Alma St	0 to 1	0 to 2
SPRR to Park Blvd	1 to 3	1 to 3

Since proposed floodwall heights in this reach are no greater than six feet as measured from the lowest adjacent grade, significant visual impacts are essentially mitigated. Six feet is the height of typical privacy fences in residential areas.

Construction Procedures

Proposed floodwall and headwall improvements within Reach 2C are similar to those described for Reach 2A, as are the construction procedures. Some reach-specific modifications, however, are listed below.

Warped Transition Construction at Alma Street. Construction for the warped transition at Alma Street will use the procedures described for channel modification in Reach 2B, but without the need for temporary shoring. Access to the work sites will be from District rights-of-way, either on the gravel maintenance access roads adjacent to the channel bank, or along the channel itself.

The current channel transition in this location is warped, but the warping begins on the south side of the local storm drain rather than the Matadero Creek culvert itself (Photo 2-7). This leads to increased downstream turbulence, energy loss, and higher upstream water surface elevations.

Proposed channel improvements in this location will provide a warped transition that begins on the south abutment of the Alma Street culvert, transitioning to the existing channel side slope downstream. A smooth transition is essential to provide improved culvert hydraulics and the water surface profile upstream of the railroad indicated on the Plates.

Prior to construction, a temporary coffer dam and diversion will be installed to bypass low flows that can remain in the channel, even during the summer months.

To accommodate the storm drain outfall, a concrete form such as Sonetube, or large diameter polyethylene drainage pipe will be used to extend the drain outlet to the face of the transition, and then be cut to shape. Steel reinforcement will be doweled into the existing channel lining and concrete cast in place then compacted and floated.

Bridge Headwall Modifications. At the Ross Road and Waverley Street bridges, headwalls are modified Caltrans Standard Type 26 barriers with Caltrans standard tubular hand railing. To modify these headwalls, the following construction methods will be used (Figure 7-6):

- remove existing tubular hand railing
- dowel into the top of the existing headwall
- place reinforcement and cast the wall extension in place

Construction Impacts and Mitigation

Short-term impacts during construction and requisite mitigation are identical to those described for Reach 2A. In Reach 2C there are no direct impacts to wildlife since the entire reach is concrete-lined channel.

Reach 2C Construction Costs

Project work in Reach 2C is estimated to cost $2.7 million (Appendix E).

POST-PROJECT CONDITIONS

After the completion of the recommended project, the area at risk of damage during a one-percent flood is substantially reduced as shown on Figure 7-8. However, residual floodplains due to tidal inundation and San Francisquito Creek overflows will remain. Mapped tidal hazards will not be eliminated until outboard levees along San Francisco Bay are certified.

The recommended project reduces estimated one-percent riverine flood damage from $320 million to $120 million. Table 7-8 summarizes estimated post-project flood damages, and may be compared to Table 3-2. Most of the residual one-percent flood damages are primarily attributable to the lack of one-percent capacity in the local storm drain system, which results in a one-percent floodplain at elevation 5 feet NGVD'29. This residual flood hazard area is masked by the one-percent tidal inundation limit on the Flood Insurance Rate Map, which is at elevation 8 feet NGVD'29. However, even if the tidal flooding hazard was removed, FEMA requires the mapping of residual flooding due to coincident interior drainage in watersheds confined by levee or floodwall systems.

Table 7-8
One-Percent Riverine Flood Damages
Matadero and Barron Creeks from San Francisco Bay to Foothill Expressway
After Completion of Recommended Project

Land Use	*Area Flooded (acres)*	*Number of Buildings*	*Direct Structure Damage ($1,000)*	*Direct Content Damage ($1,000)*	*Indirect Damages ($1,000)*	*Total 1% Flood Damages ($1,000)*
Residential	312	1311	$50,150	$34,830	$12,750	$97,730
Commercial	0	0	$0	$0	$0	$0
Industrial	5	18	$5,960	$10,650	$7,310	$23,910
Public Facilities	3	7	$500	$1,140	$0	$1,640
Parks	1	2	$20	$60	$0	$80
Vacant Land	0	0	$0	$0	$0	$0
Total	321	1338	$56,630	$46,680	$20,060	$123,360

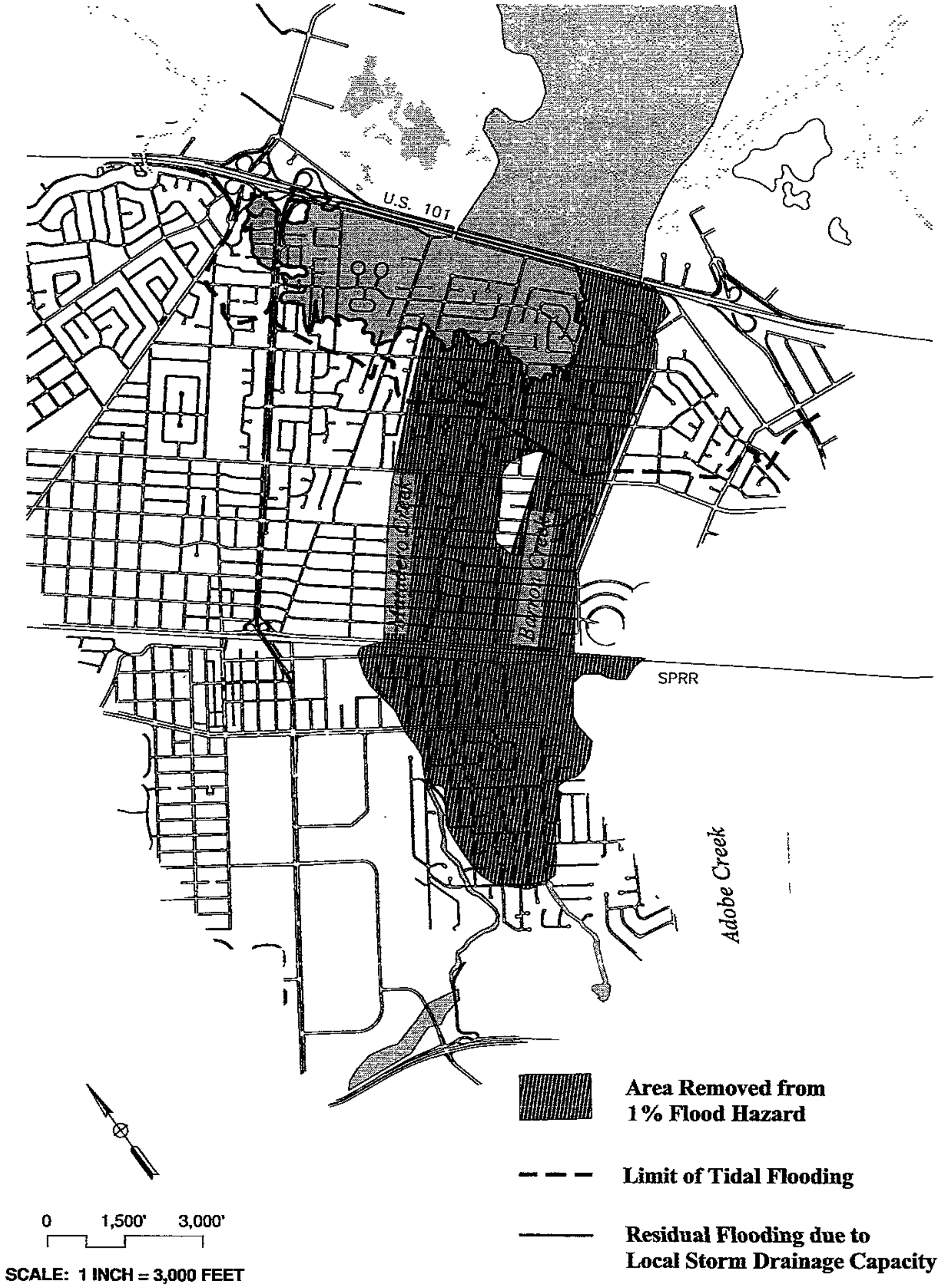

U.S. 101
Matadero Drain
Barron Creek
SPRR
Adobe Creek
▨ Area Removed from 1% Flood Hazard
- - - Limit of Tidal Flooding
— Residual Flooding due to Local Storm Drainage Capacity
0
1,500'
3,000'
SCALE: 1 INCH = 3,000 FEET

Figure 7-8

Reduction in Riverine Flood Risk After Project Remediation

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CHAPTER 8
MAINTENANCE PROGRAM

INTRODUCTION

A maintenance program is necessary to ensure the continued functionality and flood protection benefits provided by the recommended Matadero/Barron Creeks Remediation Project. This chapter outlines proposed maintenance activities of the District for Matadero and Barron Creeks. After approval of this document, these guidelines will supersede the existing maintenance program, which was developed in the 1988 Engineer's Report.

MAINTENANCE ACTIVITIES

Maintenance activities will be performed in accordance with governing regulatory permits, including a Routine Maintenance Activities in Improved Channels Memorandum of Understanding (MOU) and Streambed Alteration Permits with the California Department of Fish and Game, and Section 404 of the Clean Water Act administered by the US Army Corps of Engineers. All maintenance activities will be performed within District right-of-way.

Routine maintenance activities include the removal of natural and man-made debris (such as shopping carts), and accumulated sediment, particularly downstream of Ross Road. Other maintenance issues include periodic repair of damaged channel lining or floodwall, and potential graffiti eradication, which does not appear to be a significant problem at this time. Sediment removal will remain the primary focus of maintenance activities after project remediation is complete.

SEDIMENT MANAGEMENT

Sediment originates from the upland areas of the Matadero Creek catchment, and is transported down the natural and concrete channels, with a portion of that transported sediment reaching the natural channel downstream of Highway 101. Significant volumes of sediment have been deposited within the overbank of this channel reach. These deposits are believed to exacerbate flooding potential for urban areas upstream of Highway 101. The selection of an upstream project will not substantially alter sediment management practices since the upstream reach of channel most prone to sedimentation, (Highway 101 to Greer Road) is not changed by either project scenario.

Sediment Transport Capacity

Sediment transport capacity is defined as the ability of flowing water to move sediment downstream. A variety of variables can be used to quantify the magnitude of sediment transport capacity, but the product of unit weight of water (γ), flow depth (y), flow velocity (v) and energy slope (s) has been found to be a good predictor. This product is known as the stream power per unit area of the channel bed, that is:

$$\text{Stream Power} = \gamma \cdot y \cdot v \cdot s$$

The impact of potential changes to a channel design on sediment transport capacity can be assessed with this equation. For example, if water is diverted out of a channel, the product of velocity, flow depth and energy slope of the flowing water remaining in the channel is likely to diminish. This implies that the sediment transport capacity of the water remaining in the channel may decrease.

Sediment Availability

Sediment availability determines, concurrently with the transport capacity, how much sediment a stream will carry. For example, if a stream can carry 10 pounds of sediment per second, but upstream erosion creates only 5 pounds of sediment per second available for transport, then the sediment carried by the stream cannot exceed 5 pounds of sediment per second. Conversely, if 10 pounds of sediment per second is available to be transported by a stream, but its sediment transport capacity is only 5 pounds of sediment per second, then only 5 pounds of sediment per second will be transported. The remainder will settle out of the water column.

Sediment Load

Sediment load consists of wash, suspended and bed loads. Wash load is made up of very fine, colloidal particles such as clay, that often remain in suspension even when the sediment transport capacity of the water reduces significantly. Suspended load consists of fine sediment particles, and can settle onto the riverbed or flooded overbank areas if the sediment transport capacity of the water reduces enough. Bed load is coarser material that moves along the riverbed as flowing water drags it along. It stops moving when the sediment transport capacity of the water is reduced.

If flow in a channel is high enough to overtop its banks, the bed load usually remains in the main channel and the suspended and wash load are contained in the water column within the main channel and in the water column over the flooded overbank area. The sediment transport capacity in the main channel is often large enough to maintain suspension of the suspended load within this water column, but the transport capacity can be reduced in the flooded overbank area and deposit the suspended sediment (and sometimes even the wash load).

Maintenance Flow

A typical natural cross-section of a stream in flat areas consists of a main channel and an overbank (also known as a floodplain). Research and field observations over many years suggest that the water discharge capacity of the main channel (i.e. the volume of water that it can discharge per second when it flows full to the edge of its bank) is equivalent to approximately the two-year recurrence interval flow. When the discharge in the stream exceeds this flow magnitude, it overtops its banks with water flowing onto the floodplain.

SEDIMENT MANAGEMENT PLAN

The overflow bypass in Reach 1 will help to more effectively manage sediment in this channel reach. The intention of the overflow bypass alternative is to divert the flood water away from the vegetated overbank areas in the outfall reach. This is expected to result in less deposition of sediment on the overbanks in the long term, in addition to providing flood relief in the creek reaches upstream of Highway 101. This appears to be a feasible sediment management technique, provided that the overflow bypass area is maintained.

It is likely that sediment will be deposited in the general vicinity of the bypass entrance during high flow conditions. The entrance to the bypass will be elevated above the bed of the current outfall of Matadero Creek by about six feet, allowing floods with a magnitude greater than the 2-year to 5-year recurrence interval to flow through the bypass. Water that is diverted into the bypass will carry a portion of the suspended sediment load from Matadero Creek. Sediment load remaining in the original channel downstream of the entrance to the diversion channel will consist of bed load and the remainder of the suspended load.

Sediment transport capacity in the Matadero Creek main channel will likely be reduced downstream of the bypass inlet. Depending on the availability of sediment, this can potentially result in deposition of sediment in the reach of Matadero Creek just downstream of the inlet. If the available sediment load in Matadero Creek downstream of the inlet exceeds the sediment transport capacity in this reach, it is reasonable to expect some deposition of sediment, which will need to be removed periodically.

The potential for sediment deposition in the bypass itself depends on the balance between the availability of sediment and sediment transport capacity of the flows entering the bypass. Regardless of this balance, some sediment will continue to be deposited. Some of the sediment will be diverted off into the north side of the bypass and deposited in the existing riparian area. This is due to water being 'tapped off' to the side of the channel because of the higher roughness in the overbank. The resulting turbulence will lead to energy losses and sediment deposition.

It is also likely that sediment will deposit in the vicinity of the sweeping bypass bend, due to the energy loss and reduction in flow velocity that will result because of the bend in the channel and flow escaping into the overbank. Deposition is also likely to occur along the downstream wetlands margin as more water is 'tapped off' to the flood basin, and the conveyance area expands.

One conclusion that can be made from the qualitative analysis presented above is that the bypass channel will need periodic maintenance. Sediment that is expected to deposit at the bypass entrance in Matadero Creek and along the length of the bypass itself during flood conditions will require removal from time to time. The extent of the maintenance efforts will be a function of the balance between sediment transport capacity and sediment availability.

Average annual sediment removal quantities are assumed to be similar to the averaged total sediment accumulated from 1971 to 1999, or 900 cubic yards per year. Unit costs for sediment removal have been provided by the District, and are compiled for this reach in Appendix E.

MAINTENANCE ACTIVITIES OUTLINED BY REACH

The following maintenance activities, in addition to the aforementioned activities, are specific to certain sections of Matadero Creek and Barron Creek.

Operations and Maintenance Responsibilities

The operations and maintenance of Matadero and Barron Creeks are the responsibility of the Santa Clara Valley Water District. Ms. Jennie Micko, the West Watershed Program Manager, directs the operations and maintenance procedures for these two creeks.

Monitoring Procedures and Maintenance Triggers

Matadero and Barron Creeks are both inspected annually to assess channel conditions and sediment removal requirements. The following thresholds have been set to trigger channel maintenance and/or sediment removal for various portions of each creek, as described below. Maintenance procedures are provided in summary form in Tables 8-1 and 8-2 at the end of this chapter.

1) Matadero Creek - Palo Alto Flood Basin to Highway 101

    - Vegetation growth along the banks of the low-flow channel is to be trimmed to maintain a minimum clear floodway of approximately 20 feet.

    - Sediment deposition along the bottom of the low-flow channel shall be monitored by ground survey every year for a period of five years. After the five-year period, the need for sediment removal will be determined.

    - Sediment within the overflow bypass at the downstream side of Highway 101 is to be removed when it exceeds a depth of one foot above the concrete channel lining.

- Sediment within the sediment basin at the entrance of the bypass shall be removed when it exceeds a depth of two feet as measured at the concrete invert.

- Sediment deposition under East Bayshore Road will be inspected annually. Sediment will be removed from underneath East Bayshore Road to 100 feet downstream when sediment depth reaches one foot.

2) Matadero Creek - Under Highway 101 to West Bayshore Road

- Debris shall be removed from the nose of the bridge pier at Highway 101 when it exceeds a total width of 3 feet.

- Sediment under Highway 101 will be removed when it exceeds a depth of 1 foot above the concrete invert. This work is to be performed in conjunction with maintenance under East Bayshore Road and downstream for a distance of 100 feet.

3) Matadero Creek - West Bayshore Road to Greer Road

- Sediment within the entire reach will be removed when sediment reaches an average depth of 1 foot above the concrete invert at Highway 101 or in conjunction with sediment removal under Highway 101. (Highway 101 was selected to provide a fixed reference point for sediment depth.)

- Emergent vegetation will grow in the natural channel bottom upstream of Highway 101 and must be completely removed when it exceeds a height of 4 feet.

4) Matadero Creek - Greer Road to Alma Street

- Remove sediment when an average sediment depth of one foot is reached.

- Vegetation growing on bottom sediments is to be removed when height of the growth exceeds 4 feet. The upstream side of the bridge piers at Greer Road will be regularly inspected and debris removed from the pier noses when the width exceeds 3 feet.

5) Matadero Creek - Alma Street to Park Boulevard

- Debris will be removed from the nose of the splitter wall upstream of the Southern Pacific Railroad Bridge when a width of 3 feet is exceeded.

- Remove sediment from the channel bottom when the average depth exceeds 1 foot.

6) Matadero Creek - Park Boulevard to El Camino Real

   - Sediment will be removed when it reaches an average depth of 1 foot.
   - If vegetation becomes established in the sediment deposits, both will be removed when the height of vegetation exceeds 4 feet.

7) Matadero Bypass Channel - Bol Park to El Camino Real Confluence

   - If sediment deposits in the bypass, it will be removed when the depth exceeds an average depth of 1 foot.
   - The diversion structure at the inlet will be kept free of debris, vegetative growth and sediment accumulation. All vegetation, sediment, or debris exceeding 1 foot in height and within 30 feet of the intake will be removed from the channel. All debris should be removed from the trashrack at the intake.

8) Matadero Creek - El Camino Real to Bol Park

   - The natural creek channel in this reach is to be monitored for erosion, debris jams and vegetation growth. Debris jams or heavy growth of vegetation is to be removed to allow floodwaters to pass unimpeded.

9) Matadero Creek - Bol Park to Hillview Avenue

   - Debris and sediment deposits in the stilling basin will be removed when an average depth of 2 feet is exceeded.
   - Vegetation is to be removed from the natural channel bottom when it exceeds a diameter of 4 inches or a height of 4 feet.

10) Matadero Creek - Hillview Avenue to Foothill Expressway

   - Debris or obstruction will be removed from the natural channel bottom in this reach when a height of 4 feet is exceeded.
   - Vegetation will be removed from the channel bottom when a diameter of 4 inches or a height of 4 feet is exceeded.

11) Barron Creek - Adobe Creek Confluence to Louis Road

   - Sediment is to be removed when an average depth of 2 feet is exceeded.

- Debris or obstruction will be removed from the natural channel bottom in this reach when a height of 4 feet is exceeded.
- Vegetation will be removed from the channel bottom when a diameter of 4 inches or a height of 4 feet is exceeded.

12) Barron Creek - Louis Road to Laguna Avenue

- The reach between El Camino Real and Laguna Avenue is an underground pipe, which is inspected twice annually for possible sediment and debris removal.
- At the upstream end is a trashrack that is inspected on a regular basis for debris removal and .

13) Barron Creek - Laguna Avenue to Sediment Basin

- Maintenance measures in the natural channel between Laguna Avenue and Gunn High School consist of removing major obstructions to flow such as fallen trees or debris.
- Vegetation will be removed from the channel bottom when a diameter of 4 inches or a height of 4 feet is exceeded. The reach of creek that flows via a pipe across Gunn High School *is inspected twice annually for debris and sediment.*

Protocol for Removal and Disposal of Accumulated Sediments/Debris

In the future the Stream Maintenance Permit will allow for the routine maintenance activities prescribed herein. Sediment is removed using heavy equipment which is situated along maintenance roads adjacent to the creek. Access ramps are also available to allow the equipment to operate along the concrete-lined channel bottom for ease of sediment removal. Appropriate best management practices are implemented to protect water quality and environmental resources. (See Appendix J for a listing of these BMPs.) The sediment is properly disposed of at a landfill or approved reuse site.

Table 8-1
Maintenance Standards for Vegetation and Sediment Removal
Matadero Creek

Facility Type	Maintenance Issue	Acceptable Maintenance Limit	Performance Criteria
Reach 1 Matadero Creek—Palo Alto Flood Basin to Highway 101 (Mitigated in Project Permits)			
Unmodified Channel	Overhanging vegetation	20-foot clear floodway along creek channel	Trim overhanging vegetation by mechanical means
	Sediment accumulation	To be determined after 5-year study	To be determined after 5-year study
Overflow Bypass	Sediment accumulation	1 foot of sediment depth in bypass; 2 feet of sediment in sediment basin	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs
100 feet down stream of East Bayshore Road to Highway 101	Sediment accumulation	1 foot of sediment depth under East Bayshore Road	Remove sediment
Reach 2A Matadero Creek—Under Highway 101 to Louis Road (Mitigated Under Stream Maintenance Program)			
Unmodified Channel Bottom	Debris accumulation	Debris width reaching 3 feet or greater at nose of bridge piers	Remove debris
	Sediment accumulation	1 foot of sediment depth at Highway 101	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs
Concrete-Lined Channel	Debris accumulation	Debris width reaching 3 feet or greater at nose of bridge piers	Remove debris
	Sediment accumulation	1 foot of sediment depth	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs
Reach 2B Matadero Creek—Louis Road Bridge (Mitigated Under Stream Maintenance Program)			
Concrete-Lined Channel	Debris accumulation	Debris width reaching 3 feet or greater	Remove debris
	Sediment accumulation	1 foot of sediment depth	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs

Table 8-1
Maintenance Standards for Vegetation and Sediment Removal
Matadero Creek
(continued)

Facility Type	Maintenance Issue	Acceptable Maintenance Limit	Performance Criteria
Reach 2C Matadero Creek—Louis Road to Alma Street (Mitigated Under Stream Maintenance Program)			
Concrete-Lined Channel	Debris accumulation	Debris width reaching 3 feet or greater	Remove debris
	Sediment accumulation	1 foot of sediment depth	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs
Reach 3 Matadero Creek—Alma Street to Park Boulevard (Mitigated Under Stream Maintenance Program)			
Concrete-Lined Channel	Debris accumulation	Debris width reaching 3 feet or greater	Remove debris
	Sediment accumulation	1 foot of sediment depth	Remove sediment
Reach 4 Matadero Creek—Park Boulevard to El Camino Real (Mitigated Under Stream Maintenance Program)			
Concrete-Lined Channel	Sediment accumulation	1 foot of sediment depth	Remove sediment
	Emergent vegetation	Up to 4 feet in height	Remove completely when sediment removal occurs
Reach 5 Matadero Bypass Channel—Bol Park to El Camino Real Confluence (Mitigated Under Stream Maintenance Program)			
Concrete-Lined Bypass	Diversion structure	Vegetation, debris or sediment up to 1 foot in height	Remove vegetation, debris or sediment within 30 feet of intake. Remove debris from intake.
	Sediment accumulation	1 foot of sediment depth	Remove sediment

Table 8-1
Maintenance Standards for Vegetation and Sediment Removal
Matadero Creek
(continued)

Facility Type	Maintenance Issue	Acceptable Maintenance Limit	Performance Criteria
Reach 6 Matadero Creek—El Camino Real to Bol Park (Mitigated Under Stream Maintenance Program)			
Unmodified channel	Debris jams	Debris present	Remove debris
	Erosion	Present	Repair
	Emergent vegetation	Heavy growth	Remove by hand labor and aquatic herbicides to grade and chemically treat stumps from toe to toe of channel
Reach 7 Matadero Creek—Bol Park to Hillview Avenue (Mitigated Under Stream Maintenance Program)			
Unmodified channel	Emergent vegetation	Height of 4 feet or 4-inch diameter	Remove by hand labor and aquatic herbicides to grade and chemically treat stumps from toe to toe of channel
Stilling Basin	Debris/sediment deposits	2 feet sediment/debris	Remove sediment or debris
Reach 8 Matadero Creek—Hillview Avenue to Foothill Expressway (Mitigated Under Stream Maintenance Program)			
Unmodified channel	Debris accumulation	4 foot of debris depth	Remove debris
	Emergent vegetation	Up to 4 feet in height or 4-inch diameter	Remove by hand labor and aquatic herbicides to grade and chemically treat stumps from toe to toe of channel

Table 8-2
Maintenance Standards for Vegetation and Sediment Removal
Barron Creek

Facility Type	Maintenance Issue	Acceptable Maintenance Limit	Performance Criteria
Reach 1 Barron Creek—Adobe Creek Confluence to Louis Road (Mitigated Under Stream Maintenance Program)			
Concrete-Lined channel	Sediment accumulation	2 feet of sediment depth	Remove sediment
	Debris or obstruction	4 feet high obstruction	Remove debris or obstruction
	Emergent vegetation	4 feet high or 4-inch diameter	Remove vegetation
Reach 2 Barron Creek—Louis Road to Laguna Avenue (Mitigated Under Stream Maintenance Program)			
Concrete-Lined channel	Sediment accumulation	2 feet of sediment depth	Remove sediment
	Debris or obstruction	4 feet high obstruction	Remove debris or obstruction
	Emergent vegetation	4 feet high or 4-inch diameter	Remove vegetation
Underground Pipe	Sediment/debris accumulation	Present	Twice annual inspection and removal
	Debris accumulation on trashrack at upstream end of pipe	Present	Twice annual inspection and removal
Reach 3 Barron Creek—Laguna Avenue to Sediment Basin (Mitigated Under Stream Maintenance Program)			
Unmodified channel	Debris accumulation	Present	Remove debris
	Emergent vegetation	4 feet high or 4-inch diameter	Remove by hand labor and aquatic herbicides to grade and chemically treat stumps from toe to toe of channel
Underground pipe	Sediment/debris accumulation	Present	Twice annual inspection and removal
Reach 4 Barron Creek—Sediment Basin to Foothill Expressway (Mitigated Under Stream Maintenance Program)			
Unmodified channel	Debris accumulation	Present	Remove debris
	Emergent vegetation	4 feet high or 4-inch diameter	Remove by hand labor and aquatic herbicides to grade and chemically treat stumps from toe to toe of channel

CHAPTER 9
PROJECT COST, FINANCING, AND STAGING

PROJECT COST

The estimated total first cost of the proposed remediation project for Matadero and Barron Creeks is $14,000,000 and includes costs for design engineering, construction, inspection, administration, and mitigation (see Table 1-1 for details). Planning costs, including the preparation of the Engineer's Report and Environmental Impact Report, the costs to obtain necessary permits, and potential environmental enhancements beyond required mitigation are not included in this estimate.

FINANCING

Proposed project measures will be funded by the District's capital funds allocated to the Matadero and Barron Creeks Remediation Project in the Lower Peninsula Watershed. A total of $24 million has been allocated for planning, permit acquisition, engineering, construction, inspection and administration.

STAGING

Project construction could commence in Spring 2003. Anticipated construction schedules for each of the major project elements are listed below:

Overflow Bypass	12	months
Louis Road Bridge Replacement	6	months
Channel Modifications	3	months
Floodwall Improvements	9	months
Headwall Improvements	3	months

The aggregate construction schedule is 33 months, or about three years. However, the time window available for in-channel work will likely be limited by regulatory permit conditions. Therefore, to complete the construction of all project remediation elements within two years, it will be necessary to work within several reaches concurrently. The proposed construction staging plan is outlined below:

Year	Reach	Work Schedule
2003	Reach 1	In-Channel Work for Overflow Bypass
	Reach 2A	Floodwall Improvements
	Reach 2B	Louis Road Bridge and Channel Modifications
	Reach 2C	Floodwall Improvements, Louis Road to Middlefield Road
2004	Reach 1	Floodwall Construction for Overflow Bypass
	Reach 2C	Floodwall Improvements, Middlefield Road to Alma Street
	Reach 2C	New Transition at Alma Street
2005		Project Acceptance Mitigation and Monitoring
2006		Mitigation and Monitoring

Bridge replacement and channel modifications at Louis Road will be performed at the same time. Headwall modifications at bridges will be made concurrently with floodwall improvements in adjacent reaches. If necessary or desirable, this remediation project can be broken into smaller contracts. For instance, Reach 1 work is distinct from Reach 2 work both in scope and location. (Highway 101 divides the project limits.) Also, the Louis Road bridge replacement and associated road work are unique enough to the project for separate contracts. A bridge location such as Middlefield Road would also make a convenient separation between contracts. After project acceptance, the mitigation and monitoring phase would begin with new design and construction contracts.

CHAPTER 10

CONCLUSIONS AND RECOMMENDATIONS

Matadero and Barron Creeks do not currently provide flood protection meeting the national standard. A one-percent flood from the two creeks would affect about 5,400 structures and result in estimated flood damages of $320 million. As a result of proposed project remediation, an additional 4,000 structures will be protected from one-percent freshwater flooding, thereby reducing estimated riverine flood damages to $120 million. Most of this damage would be caused by capacity limitations in the local storm drain system that are outside of the District's jurisdiction.

Proposed capital improvements provide added protection from the one-percent flood and accomplish project objectives outlined in this document. Beneficial impacts of project implementation include:

• Flooding	Provides flood damage reduction from a one-percent flood.
• Maintenance	New facilities between Highway 101 and the PAFB, combined with the proposed maintenance plan, will allow the District to effectively maintain the integrity of the channel system.
• Sedimentation	Accumulated sediment may be more easily removed from downstream reaches.
• Local Drainage	Sediment removal and increased capacity will improve local drainage conditions by decreasing the duration and frequency of flooding in the streets and localized ponding. Increased floodwall elevations will not adversely impact local drainage, since the wall extensions are providing additional freeboard rather than containing water.
• Riparian Vegetation	Project impacts to jurisdictional habitat are fully mitigated. The District already owns enough suitable land for mitigation.
• Wildlife Habitat	Onsite impacts and impacts to adjacent lands are mitigated.

Therefore, it is recommended that the proposed creek remediation be approved by the Board, and construction plans be prepared for implementation of the project.

APPENDICES

APPENDIX A
LIST OF TECHNICAL TERMS AND ACRONYMS

Acre-Foot	A quantity of water that would cover 1 acre to a depth of 1-foot, equal to about 325,000 gallons.
Aggradation	The geologic process by which streambeds and floodplains are raised in elevation by the deposition of material eroded and transported from other areas. It is the opposite of *degradation.*
Alluvial	Deposition by the action of running or receding water.
Amortization	The process of liquidating a debt by installing payments or payment into a sinking fund; to prorate over a defined period at a specified interest rate.
Antecedent	An event that precedes another event.
Aquatic Herbicides	Herbicides that are approved by Federal and State authorities for use on vegetation in or near water bodies, such as creeks or lakes. When aquatic herbicides are applied, the solution which is not absorbed by plant tissue ends up on the soil or in the water. The composition of the herbicide allows it to bind easily and strongly to soil particles (either on the ground or those which are suspended in water). In a relatively short time, the herbicide breaks down readily into harmless chemical compounds (carbon, oxygen, etc.). Until this occurs, the herbicide is tied up in the soil. For these reasons, aquatic herbicides are not considered a hazard to water quality. The District has state licensed vegetation technicians that apply herbicides.
Backwater	Water held back by a downstream control such as a bridge, constricted channel, or tide.
Base Flood	See *one-percent flood.*
Bed Load	Sediment bouncing or rolling along the bottom of a stream. See also *suspended load.*
bgs	Below ground surface.
BMP	Best Management Practice.

Bridge Pressurization	This occurs when the water surface in a stream channel rises so that it makes contact with the underside of a bridge structure. In such circumstances, the flow characteristics are more reflective of closed pipe (or pressurized) flow than open channel flow, which has a free water surface.
Bypass	A facility in which floodwater is *diverted* around a channel reach with limited capacity.
Caltrans	California Department of Transportation.
CDFG	California Department of Fish and Game.
CEQA	California Environmental Quality Act.
Channel Forming Discharge	The dominant *discharge* that causes natural channels to form, usually equivalent to the 50-percent (2-year) discharge. Also known as bank-full discharge.
City	City of Palo Alto, California.
Confluence	The junction of two streams.
Conveyance	The ability of a stream or channel to pass a certain rate of flow.
Critical Flow	Water is moving just as fast, relative to the channel banks, as the wave resulting from a small disturbance moves relative to the water. Standing waves are characteristic of critical flow conditions. Critical flow conditions can be unstable. See also *subcritical flow* and *supercritical flow.*
Cross Section	A vertical section of a stream channel or structure that provides a side view of the structure; a transect taken at right angles to flow direction.
Cubic Feet Per Second (cfs)	A rate of flow equivalent to 1 cubic foot, about 7 ½ gallons, passing a point during 1 second (approximately 450 gallons/minute).
Degradation	The geologic process by which stream and river beds lower in elevation. It is the opposite of *aggradation.*

Delta	An *alluvial* deposit at the mouth of a stream or river.
Design Flow	The magnitude of streamflow (see *discharge*) that is used in design of channel modifications and structures across channels.
Discharge	The volume of water passing through a channel during a given period of time. Usually measured in cubic feet per second.
District	Santa Clara Valley Water District.
Diversion	A planned transfer of water from one *watershed* or system to another.
EIR	Environmental Impact Report.
El Niño	A disruption of the ocean-atmosphere system in the Tropical Pacific having important consequences for weather and climate around the globe. An El Niño tends to increase rainfall across the southern tier of the United States. The 1997-1998 El Niño was very strong, and caused destructive flooding throughout Northern California.
Ephemeral Stream	A stream that flows briefly only in direct response to precipitation in the immediate locality and whose channel is at all times above the water table. Matadero and Barron Creeks are primarily ephemeral. Water present during the dry season may accumulate from groundwater, irrigation runoff, or backwater from the Palo Alto Flood Basin. See *perennial streams*.
EPA	Environmental Protection Agency.
ER	Engineer's Report.
FCE	Flood control easement.
FEMA	Federal Emergency Management Agency.
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study

Fish Passage	A term used to identify sections of the creek that can be navigated by migrating fish. Includes low-flow channels with barriers, drop structures that fish can jump, etc.
Floodplain	An area of land inundated by *floodwaters*. Floodplains may consist of standing or moving water.
Floodwaters	Those flows of water that cannot be contained within the natural stream channel.
Freeboard	Vertical distance between the top of an embankment adjoining a channel and the water level in the channel. It is a factor of safety designed into a project.
Gravel	Sediment particles larger than sand and ranging from 0.25 to 3 inches in diameter.
Hydraulic Jump	The transition of flow from the *supercritical* to the *subcritical* condition; the change characterized by turbulence and energy loss.
Hydrograph	A plot of *discharge* (flow) against time.
Low Flow Channel	A subchannel of the main stream channel that is designed to concentrate low flows for biological or aesthetic reasons.
MHHW	Mean Higher High Water: The arithmetic mean of the daily high tides observed over a specific 19-year period known as the National Tidal Datum Epoch.
MLLW	Mean Lower Low Water: A tidal datum. The arithmetic mean of the lowest daily tides observed during the 19-year National Tidal Datum Epoch.
Mean Sea Level	The average height of the surface of the sea of all stages of the tide over a 19-year period.
Mitigation	To moderate, reduce, alleviate the impacts of a proposed activity; includes, in order: (a) avoiding the impact by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation;

Mitigation (contd.)	c) rectifying the impact by repairing, rehabilitation, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; (e) compensating for the impact by replacing or providing substitute resources or environments (Council of Environmental Quality, 1978).
MSC	City of Palo Alto Municipal Services Center.
National Geodetic Vertical Datum (NGVD)	The *mean sea level* in 1929.
NFIP	National Flood Insurance Program.
NPDES	National Pollutant Discharge Elimination System.
One Hundred Year Flood	Synonymous with the *one-percent flood.*
One-Percent (1%) Flood	A flood magnitude that has a one percent chance of being equaled or exceeded in any one year.
Ordinary High Water	The area of a watercourse subject to Section 404 of the Federal Clean Water Act of 1972. The area affected is determined by the elevation of the 2.3-year flood event (ordinary high water flow) which is field checked by biologists using physical characteristics.
Overbank	In a river or creek, the area between the main channel and the limits of the *floodplain.*
Overflow	*Floodwater* that leaves a channel over its bank(s).
PAFB	Palo Alto Flood Basin.
Perennial Stream	A stream that flows continuously throughout the year. See also *ephemeral stream.*
PI/P	Public Information/Participation Program.

PVC	Polychlorinated Vinyl Pipe.
RCP	Reinforced Concrete Pipe.
Reach	A subdivision of the creek for convenience of study and reference.
Riparian	Vegetation and wildlife living within, and immediately adjacent to a river, stream or lake. In this report, riparian means the creek environment.
Riverine Flooding	Flooding from a freshwater source such as a river, creek, or stream.
Roughness Coefficient	Represents the frictional resistance of a surface to the flow of water. Used in hydraulic computations.
RWQCB	Regional Water Quality Control Board.
Sacked Concrete Slope Protection (SCSP)	Burlap bags filled with concrete and placed on a stream bank to protect the bank against erosion.
SCVWD	Santa Clara Valley Water District.
Sequent Depth	Corresponding water depths upstream and downstream of a *hydraulic jump,* also known as conjugate depth.
SFHA	Special Flood Hazard Area
SPRR	Southern Pacific Railroad.
Subcritical Flow	Flow conditions in which a wave from a disturbance moves upstream. Also known as Tranquil Flow. See also *backwater.*
Supercritical Flow	Flow conditions in which a wave from a disturbance moves downstream. Also known as Rapid Flow. Supercritical flow conditions can lead to high velocities and shock wave formation at the location of channel geometry changes.
Suspended Load	The part of the total sediment load that is carried for a considerable period of time at the velocity of the flow, free from contact with the streambed. See also *bed load.*

SWPPP	Storm Water Pollution Prevention Plan.
SWRCB	California State Water Resources Control Board.
Tidal Flooding	Flooding from a saltwater body subject to influence from tides, such as an ocean, estuary, or bay.
USACE	United States Army Corps of Engineers.
USFWS	United States Fish and Wildlife Service.
USGS	United States Geological Survey.
VCP	Vitrified clay pipe.
Wash Load	The part of the *suspended load* comprised of very fine, colloidal particles such as clay.
Watershed	The geographical region or area drained by a stream. Also referred to as a drainage basin or tributary.
Wetlands	As used herein, areas that under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology.
WWTP	Wastewater treatment plant.

APPENDIX B
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APPENDIX E
DETAILED COST ESTIMATES

BASIS OF COST ESTIMATING

Project costs for conceptual and feasible alternatives are estimated on a unit cost basis for construction with a 10 percent markup for mobilization, and a 20 percent allowance for engineering, construction management, and administration. Right-of-way acquisition is added to the construction cost, and a 25 percent contingency is applied to the sum for total estimated project cost.

"NO PROJECT" ALTERNATIVE

The cost of this conceptual alternative is equivalent to the benefit provided by the alternative remediation projects. This is equal to the one-percent flood damages caused by overflows from Matadero and Barron Creeks. Flood damages due to tidal flooding are excluded from the project benefits. Damages are based on the U.S. Army Corps of Engineers depth-damage chart for urban areas in Northern California. One- and two-story residential homes without basements, multi-story residential buildings, and one-story commercial/industrial categories are used. The value of various types of structures has been established using data provided by the Santa Clara County Assessor's Office for recorded land transactions between 1998 and 2000. Table E-1 summarizes average land and structure values for the categories of land use indicated on Table 3-1, 3-2, and 7-4.

Table E-1
Average Parcel Values in Palo Alto
Based on Recorded Land Transactions from 1998 to 2000

Land Use Category	*Average Structure Value*	*Average Total Parcel Value*
Residential	$200,000	$450,000
Commercial	$1,000,000	$1,700,000
Industrial	$3,500,000	$7,500,000
Public Facilities	$600,000	$1,600,000
Parks (per acre)[1]	$100,000	$2,700,000

[1] Data unavailable. Structure value assumed; parcel value based on vacant land costs.

The cost of the No Project alternative is equivalent to the freshwater flood damages prevented by implementing a project, or the difference in damage between Table 7-4 and 3-2.

NON-STRUCTURAL ALTERNATIVES

Two non-structural alternatives have been examined: land purchase and flood-proofing. The cost to purchase land and structures within the one-percent freshwater floodplain that would be removed by the remediation project is estimated based on average parcel values from Table E-1. The total number of structures purchased or flood-proofed includes structures that are also subject to tidal flooding, so that the level of freshwater flood protection is equivalent to the level of protection provided by a remediation project. The average cost to flood-proof a structure is assumed to be one-quarter of its value (FEMA, 1986).

Table E-2
Project Costs for Non-Structural Alternatives

Land Use Category	*Parcels to be Purchased or Flood-Proofed*	*Average Structure Value*	*Average Parcel Value*	*Flood-Proofing ($1,000)*	*Purchase ($1,000)*
Residential	3,231	$200,000	$450,000	$161,550	$1,453,950
Commercial	133	$1,000,000	$1,700,000	$33,250	$226,100
Industrial	58	$3,500,000	$7,500,000	$50,750	$435,000
Public Facilities	35	$600,000	$1,600,000	$5,250	$56,000
Parks (per acre)[1]	7/6 ac	$100,000	$2,700,000	$175	$16,200
TOTAL	3,464			$250,975	$2,187,250

[1] Data unavailable. Structure value assumed; parcel value based on vacant land costs.

CONCEPTUAL AND FEASIBLE PROJECT ALTERNATIVES

Estimated capital costs for conceptual project alternatives described in Chapter 5 and feasible project alternatives discussed in Chapter 6 follow in spreadsheet form. Land acquisition costs are summarized subsequent to the project estimates, based on aforementioned land transaction records. Land costs are more specific to the actual areas of necessary project or mitigation rights-of-way.

UPSTREAM RESERVOIR ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	RELOCATE PAGE MILL ROAD				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$50,000	$50,000
02.1101 031	REMOVE PAVEMENT, ASPHALTIC CONCRETE, OVER 50,000	75,000	SF	$0.15	$11,250
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	75,000	SF	$0.10	$7,500
02.2002 041	RDWY CUT & FILL, EARTH, 5,000 TO 20,000	6,000	CY	$5.00	$30,000
02.6001 041	ASPHALTIC CONCRETE, 3", 8" BASE, 10" SUB	75,000	SF	$5.00	$375,000
02.6007 181	STRIPING THERMALPLASTIC, YELLOW, 8"	6,250	LF	$3.50	$21,875
					$495,625
	NEW ROAD FOR RESIDENT ACCESS				
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	66,000	SF	$0.10	$6,600
02.2002 041	RDWY CUT & FILL, EARTH, 5,000 TO 20,000	5,000	CY	$5.00	$25,000
02.6001 041	ASPHALTIC CONCRETE, 3", 8" BASE, 10" SUB	66,000	SF	$5.00	$330,000
02.6007 181	STRIPING THERMALPLASTIC, YELLOW, 8"	5,500	LF	$3.50	$19,250
					$380,850
	RELOCATE I-280 PAGE MILL ROAD INTERCHANGE				
	TOTAL ESTIMATED COST, PER MARK THOMAS CO.[1]	1	LS	$15,000,000	**$15,000,000**
	CONSTRUCT DAM				
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	2,500,000	SF	$0.10	$250,000
02.2005 041	FILL, 25,000 TO 50,000, IMPORTED ONE MILE	200,000	CY	$7.50	$1,500,000
02.2005 081	FILL, COMPACTION BY ROLLER	200,000	CY	$2.50	$500,000
02.2008 021	BANKRUN GRAVEL	7,000	CY	$20.00	$140,000
02.2008 051	RIP RAP, MACHINE PLACED	20,000	TON	$35.00	$700,000
03.0505.000	CONCRETE SPILLWAY AND APPURTENANCES	400	CY	$800.00	$320,000
					$3,410,000
	SUBTOTAL				$19,286,475
	MOBILIZATION			10%	$1,928,648
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$4,243,025
	ESTIMATED CONSTRUCTION COST				**$25,458,147**
	MITIGATION				
	RIPARIAN MITIGATION AND MONITORING	15	AC	$200,000	**$3,000,000**
	LAND ACQUISITION				
	DAM AND RESERVOIR SITE	63	AC	$200,000	$12,500,000
	HOUSE AND LOT IN LOS ALTOS HILLS + RELOCATION	5	EA	$1,500,000	$7,500,000
	MITIGATION SITES	15	AC	$1,000,000	$15,000,000
					$35,000,000
	SUBTOTAL				$63,458,147
	ENVIRONMENTAL IMPACT REPORT AND PERMITTING	1	LS	$500,000	$500,000
	CONTINGENCY			25%	$16,041,853
	TOTAL FOR DESIGN AND CONSTRUCTION				**$80,000,000**

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[1] Average Cost of Interstate 880 / Highway 237 Interchange and US 101 / Ralston Ave. Interchange

STANFORD STORAGE ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	BASIN EXCAVATION				
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	875,000	SF	$0.10	$87,500
02.2001.041	STRIP AND STOCKPILE TOPSOIL	25,000	CY	$2.50	$62,500
02.2003.021	SITE CUT, EARTH, 50,000 TO 250,000, HAUL AWAY	250,000	CY	$5.00	$1,250,000
02.2001.061	ROUGH GRADE BY MACHINE	875,000	SF	$0.10	$87,500
02.2001.081	FINE GRADE BY MACHINE/HAND	875,000	SF	$0.35	$306,250
02.7603.021	REPLACE AND SUPPLEMENT TOPSOIL	25,000	CY	$20.00	$500,000
02.7606.011	RESEED PASTURE	875,000	SF	$0.10	$87,500
					$2,381,250
	OVERFLOW STRUCTURES				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$25,000	$25,000
02.1101 031	REMOVE PAVEMENT, ASPHALTIC CONCRETE, OVER 50,000	15,000	SF	$0.15	$2,250
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	15,000	SF	$0.10	$1,500
02.2002 041	RDWY CUT & FILL, EARTH, 5,000 TO 20,000	6,000	CY	$5.00	$30,000
02.2008 051	RIP RAP, MACHINE PLACED	850	TON	$35.00	$29,750
02.6001 041	ASPHALTIC CONCRETE, 3", 8" BASE, 10" SUB	15,000	SF	$5.00	$75,000
02.6007 181	STRIPING THERMALPLASTIC, YELLOW, 8"	300	LF	$3.50	$1,050
03.0505.000	CONCRETE SPILLWAYS AND APPURTENANCES	400	CY	$800.00	$320,000
					$484,550
	SUBTOTAL				$2,865,800
	MOBILIZATION			10%	$286,580
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$630,476
	ESTIMATED CONSTRUCTION COST				**$3,782,856**
	MITIGATION				
	RIPARIAN MITIGATION AND MONITORING	1	AC	$200,000	**$200,000**
	LAND ACQUISITION				
	STORAGE BASIN SITE	20	AC	$1,000,000	**$20,000,000**
	SUBTOTAL				$23,982,856
	CONTINGENCY			25%	$6,017,144
	TOTAL FOR DESIGN AND CONSTRUCTION				**$30,000,000**

RENZEL MARSH ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	LEVEE CONSTRUCTION				
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	450,000	SF	$0.10	$45,000
02.2004.151	CUT FOR LEVEES (3 FOOT KEYWAY) AND DISPOSAL	30,000	CY	$22.50	$675,000
02.2006.031	SELECT IMPORT, COMPACTED	60,000	CY	$35.00	$2,100,000
02.7606.011	RESEED LEVEES	450,000	SF	$0.10	$45,000
					$2,865,000
	OVERFLOW AND RETURN FLOW STRUCTURES				
02.2001 011	CLEAR, GRUB, BRUSH, TURF, ROOTS, DISPOSAL	4,000	SF	$0.10	$400
02.2002 041	REMOVE EXISTING LEVEE	150	CY	$5.00	$750
02.2008 051	RIP RAP, MACHINE PLACED	500	TON	$35.00	$17,500
03.0505.000	CONCRETE CAUSEWAY OVER SPILLWAY	250	CY	$800.00	$200,000
	PUMPING STATION	30	CFS	$20,000	$600,000
					$818,650
	SUBTOTAL				$3,683,650
	MOBILIZATION			10%	$368,365
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$810,403
	ESTIMATED CONSTRUCTION COST				**$4,862,418**
	MITIGATION				
	SALT POND CONVERSION TO MARSH HABITAT	270	AC	$100,000	$27,000,000
	RIPARIAN MITIGATION AND MONITORING	0.15	AC	$200,000	$30,000
					$27,030,000
	LAND ACQUISITION				
	SALT MARSH/PONDS FOR LEVEES AND MITIGATION	283	AC	$20,000	**$5,660,000**
	SUBTOTAL				$37,552,418
	CONTINGENCY			25%	$9,447,582
	TOTAL FOR DESIGN AND CONSTRUCTION				**$47,000,000**

COMPLETE BYPASS ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	INITIAL EXCAVATION				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$50,000	$50,000
02.1101 031	REMOVE PAVEMENT, ASPHALTIC CONCRETE, OVER 50,000	300,000	SF	$0.15	$45,000
02.2003.031	EXCAVATION IN EARTH, HAUL FROM SITE	170,000	CY	$2.50	$425,000
	DISPOSAL AT BFI LANDFILL	170,000	CY	$20.00	$3,400,000
02.4001.011	TEMPORARY SHORING	300,000	SF	$20.00	$6,000,000
	DEWATERING ALLOWANCE	1	LS	$100,000	$100,000
	UTILITY RELOCATION, ASSUME 5 UTILITIES	10,000	LF	$500	$5,000,000
					$15,020,000
	BYPASS CONSTRUCTION				
	GEOTEXTILE FABRIC	300,000	SF	$2.00	$600,000
02.2008.011	PERMEABLE BASE	12,000	CY	$25.00	$300,000
	CONCRETE STRUCTURE	25,000	CY	$800	$20,000,000
	TUNNELING AT SPRR AND HIGHWAY 101	300	LF	$25,000	$7,500,000
	MANHOLES FOR ACCESS	20	EA	$5,000	$100,000
					$27,600,000
	STREET RESTORATION				
02.2006.051	BACKFILL, SELECT IMPORT, COMPACTED	60,000	CY	$25.00	$1,500,000
02.6001 041	ASPHALTIC CONCRETE, 3", 8" BASE, 10" SUB	300,000	SF	$5.00	$1,500,000
02.6007 181	STRIPING THERMALPLASTIC, YELLOW, 8"	10,000	LF	$4.00	$40,000
					$3,040,000
	SUBTOTAL				$45,660,000
	MOBILIZATION			10%	$4,566,000
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$10,045,200
	ESTIMATED CONSTRUCTION COST				**$60,271,200**
	MITIGATION				
	WETLAND MITIGATION AND MONITORING	0	AC	$200,000	**$4,000**
	SUBTOTAL				$60,275,200
	CONTINGENCY			24%	$14,724,800
	TOTAL FOR DESIGN AND CONSTRUCTION				**$75,000,000**

DOWNSTREAM BYPASS ALTERNATIVE - OVERFLOW BYPASS

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	SITE PREPARATION				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$2,000	$2,000
02.1102.011	REMOVE FENCING, SALVAGE	1,400	LF	$2.50	$3,500
02.1104.011	REMOVE TREES	20	EA	$400	$8,000
02.2001.011	CLEAR & GRUB, DISPOSAL	112,000	SF	$0.10	$11,200
					$24,700
	EXCAVATION				
02.2003.031	EXCAVATION	36,000	CY	$2.50	$90,000
	DISPOSAL AT BFI LANDFILL	36,000	CY	$20.00	$720,000
02.4001.011	TEMPORARY SHORING	17,000	SF	$20.00	$340,000
					$1,150,000
	CONCRETE STRUCTURES				
	GEOTEXTILE FABRIC	84,000	SF	$2.00	$168,000
02.2008.011	PERMEABLE BASE/BACKFILL	7,400	CY	$25.00	$185,000
03.0505.000	STRUCTURAL CONCRETE	2,400	CY	$800.00	$1,920,000
	CONCRETE BLOCK WALL	15,400	SF	$25.00	$385,000
02.2006.041	BACKFILL, SELECT IMPORT, COMPACTED	5,000	CY	$25.00	$125,000
					$2,783,000
	SITE RESTORATION				
02.7602.031	LANDSCAPING, FENCING	14,000	SF	$1.00	$14,000
	MISCELLANEOUS	1	LS	$6,000.00	$6,000
					$20,000
	SUBTOTAL				$3,977,700
	MOBILIZATION			10%	$397,770
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$875,094
	ESTIMATED CONSTRUCTION COST				**$5,250,564**
	MITIGATION				
	HAZARDOUS MATERIALS DISPOSAL/REMEDIATION	1	LS	$500,000	$500,000
	RIPARIAN MITIGATION	2.34	AC	$200,000	$468,000
	WETLAND MITIGATION	0.22	AC	$100,000	$22,000
					$990,000
	RIGHT-OF-WAY ACQUISITION				
	SWEEPING CORNER ON MSC	0.16	AC	$1,000,000	**$160,000**
	SUBTOTAL				$6,400,564
	CONTINGENCY			25%	$1,599,436
	TOTAL FOR DESIGN AND CONSTRUCTION				**$8,000,000**

DOWNSTREAM BYPASS ALTERNATIVE - UNDERGROUND BYPASS

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	SITE PREPARATION				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$10,000	$10,000
02.1101 031	REMOVE PAVEMENT, ASPHALTIC CONCRETE, OVER 50,000	55,000	SF	$0.15	$8,250
02.1102.011	REMOVE FENCING, SALVAGE	350	LF	$2.50	$875
02.1103.011	REMOVE STORM DRAIN INLETS	4	EA	$400.00	$1,600
02.1104.011	REMOVE TREES	3	EA	$400.00	$1,200
02.1105.011	REMOVE, RESET HYDRANT	2	EA	$400.00	$800
02.2001.011	CLEAR & GRUB, DISPOSAL	32,000	SF	$0.10	$3,200
					$25,925
	UTILITY RELOCATION				
02.5106.091	STORM DRAIN	1,500	LF	$160.00	$240,000
02.5112.041	SANITARY SEWER	1,500	LF	$80.00	$120,000
02.5305.051	WATER	1,500	LF	$50	$75,000
16.5002.061	ELECTRICAL	1,500	LF	$20	$30,000
02.5307.061	20" HP GAS MAIN	1,500	LF	$240	$360,000
	MISCELLANEOUS UTILITIES (ALLOW)	1,500	LF	$50	$75,000
					$900,000
	EXCAVATION				
02.2003.031	EXCAVATION	43,000	CY	$2.50	$107,500
	DISPOSAL AT BFI LANDFILL	43,000	CY	$20.00	$860,000
02.4001.011	TEMPORARY SHORING	6,000	SF	$20.00	$120,000
					$1,087,500
	CONCRETE STRUCTURES				
	GEOTEXTILE FABRIC	75,000	SF	$2.00	$150,000
02.2008.011	PERMEABLE BASE	2,800	CY	$25.00	$70,000
03.0505.000	CONCRETE	7,500	CY	$800.00	$6,000,000
02.2006.041	BACKFILL, SELECT IMPORT, COMPACTED	7,000	CY	$25.00	$175,000
					$6,175,000
	STREET RESTORATION				
02.6001 041	ASPHALTIC CONCRETE, 3", 8" BASE, 10" SUB	55,000	SF	$5.00	$275,000
02.6005.091	CURBS, GUTTERS, SIDEWALK	3,200	LF	$20.00	$64,000
02.6007 181	STRIPING THERMALPLASTIC, YELLOW, 8"	1,500	LF	$4.00	$6,000
					$345,000
	LANDSCAPE RESTORATION				
02.7401.011	IRRIGATION	10,000	SF	$2.00	$20,000
02.7602.031	LANDSCAPING, FENCING	10,000	SF	$1.00	$10,000
02.7602.161	TREES	3	EA	$1,000.00	$3,000
					$33,000
	SUBTOTAL				$8,566,425
	MOBILIZATION			10%	$856,643
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$1,884,614
	ESTIMATED CONSTRUCTION COST				**$11,307,681**
	MITIGATION				
	RIPARIAN MITIGATION	1.08	AC	$200,000	**$216,000**
	LAND ACQUISITION				
	PERMANENT EASEMENT FOR UTILITY RELOCATION	0.25	AC	$1,000,000	**$250,000**
	SUBTOTAL				$11,773,681
	CONTINGENCY			27%	$3,226,319
	TOTAL FOR DESIGN AND CONSTRUCTION				**$15,000,000**

BARRON CREEK MODIFICATION ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	FLOODWALL MODIFICATIONS				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$10,000	$10,000
	CONCRETE FLOODWALLS TO 15' IN HEIGHT	12,000	LF	$500	$6,000,000
	SITE RESTORATION	120,000	SF	$5	$600,000
					$6,610,000
	BRIDGE REPLACEMENT				
	STRUCTURAL SLAB	8	EA	$250,000	$2,000,000
	ASSOCIATED ROADWAY WORK	8	EA	$250,000	$2,000,000
					$4,000,000
	PARALLEL CULVERT				
02.5106.161	84-INCH RCP W/ TRENCHING	4,500	LF	$250	$1,125,000
	UTILITY RELOCATION	4,500	LF	$50	$225,000
	PAVEMENT RESTORATION	67,500	SF	$5	$337,500
					$1,687,500
	SUBTOTAL				$12,297,500
	MOBILIZATION			10%	$1,229,750
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$2,705,450
	ESTIMATED CONSTRUCTION COST				**$16,232,700**
	CONTINGENCY			23%	$3,767,300
	TOTAL FOR DESIGN AND CONSTRUCTION				**$20,000,000**

CHANNEL RESTORATION ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	SITE PREPARATION				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$1,000	$1,000
02.1102.011	REMOVE FENCING, SALVAGE	1,400	LF	$2.50	$3,500
02.1104.011	REMOVE TREES	20	EA	$210.85	$4,217
02.2001.011	CLEAR & GRUB, DISPOSAL	166,000	SF	$0.12	$19,920
					$28,637
	EXCAVATION				
02.2003.031	EXCAVATION	24,000	CY	$2.50	$60,000
	DISPOSAL AT BFI LANDFILL	24,000	CY	$20.00	$480,000
02.4001.011	TEMPORARY SHORING	14,000	SF	$20.00	$280,000
					$820,000
	SITE RESTORATION				
02.7602.031	LANDSCAPING, FENCING	14,000	SF	$1.00	$14,000
	ACCESS RAMP TO CHANNEL	5,800	SF	$1.00	$5,800
	MISCELLANEOUS	1	LS	$5,200.00	$5,200
					$25,000
	SUBTOTAL				$873,637
	MOBILIZATION			10%	$87,364
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$192,200
	ESTIMATED CONSTRUCTION COST				**$1,153,201**
	MITIGATION				
	HAZARDOUS MATERIALS DISPOSAL/REMEDIATION	1	LS	$500,000	$500,000
	RIPARIAN MITIGATION	10.08	AC	$200,000	$2,016,000
	WETLAND MITIGATION	1.32	AC	$100,000	$132,000
					$2,648,000
	RIGHT-OF-WAY ACQUISITION				
	RIPARIAN MITIGATION SITES OUTSIDE DISTRICT R.O.W.	10.20	AC	$1,000,000	**$10,200,000**
	SUBTOTAL				$14,001,201
	CONTINGENCY			25%	$3,498,799
	TOTAL FOR DESIGN AND CONSTRUCTION				**$17,500,000**

EXPANDED FLOODWAY ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	SITE PREPARATION				
	TRAFFIC CONTROL, TEMPORARY DETOURS	1	LS	$1,000	$1,000
02.1102.011	REMOVE FENCING, SALVAGE	1,400	LF	$2.50	$3,500
02.1104.011	REMOVE TREES	20	EA	$210.85	$4,217
02.2001.011	CLEAR & GRUB, DISPOSAL	166,000	SF	$0.10	$16,600
					$25,317
	EXCAVATION				
02.2003.031	EXCAVATION	6,700	CY	$2.50	$16,750
	DISPOSAL AT BFI LANDFILL	6,700	CY	$20.00	$134,000
02.4001.011	TEMPORARY SHORING	8,500	SF	$20.00	$170,000
					$320,750
	SITE RESTORATION				
02.7602.031	LANDSCAPING, FENCING	14,000	SF	$1.00	$14,000
	GABION WALL FOR ACCESS	1,700	LF	$300.00	$510,000
	PAVED ACCESS IN CHANNEL	7,500	SF	$10.00	$75,000
	MISCELLANEOUS	1	LS	$5,000.00	$5,000
					$604,000
	SUBTOTAL				$950,067
	MOBILIZATION			10%	$95,007
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$209,015
	ESTIMATED CONSTRUCTION COST				**$1,254,088**
	MITIGATION				
	HAZARDOUS MATERIALS DISPOSAL/REMEDIATION	1	LS	$500,000	$500,000
	RIPARIAN MITIGATION	9.30	AC	$200,000	$1,860,000
	WETLAND MITIGATION	0.80	AC	$100,000	$80,000
					$2,440,000
	RIGHT-OF-WAY ACQUISITION				
	RIPARIAN MITIGATION SITES OUTSIDE DISTRICT R.O.W.	7.76	AC	$1,000,000	**$7,760,000**
	SUBTOTAL				$11,454,088
	CONTINGENCY			27%	$3,045,912
	TOTAL FOR DESIGN AND CONSTRUCTION				**$14,500,000**

FLOODWALL ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	REACH 2A - HIGHWAY 101 TO LOUIS ROAD				
	PRE-EXISTING WALL	240	LF	$35	$8,400
	MODIFIED WALL	1,560	LF	$34	$53,040
	TYPE II WALL	60	LF	$28	$1,680
	TYPE III WALL	2,400	LF	$35	$84,000
	TYPE V WALL	150	LF	$43	$6,450
	TYPE VIII WALL	190	LF	$36	$6,840
	BUTTRESS ASSEMBLY	4,320	LF	$210	$907,200
	GREER ROAD HEADWALL	120	LF	$150	$18,000
					$1,085,610
	REACH 2B - LOUIS ROAD				
	TRAFFIC CONTROL AND DETOURS	1	LS	$25,000	$25,000
	BRIDGE REPLACEMENT	1	LS	$175,000	$175,000
	UTILITY PROTECTION DURING BRIDGE CONSTRUCTION	1	LS	$100,000	$100,000
	CHANNEL MODIFICATION	120	LF	$2,800	$336,000
02.6001.041	ASPHALTIC CONCRETE, 3" ON 8" BASE, 10" SUB	27,500	SF	$5	$137,500
	ALLOWANCE FOR LOCAL SITE GRADING AND DRAINAGE	1	LS	$150,000	$150,000
					$923,500
	REACH 2C - LOUIS ROAD TO ALMA STREET				
	TYPE III WALL	3,910	LF	$35	$136,850
	TYPE VI WALL	300	LF	$17	$5,100
	TYPE VII WALL	3,080	LF	$50	$154,000
	TYPE VIII WALL	1,750	LF	$36	$63,000
	BUTTRESS ASSEMBLY	5,410	LF	$210	$1,136,100
	ROSS ROAD HEADWALL	110	LF	$100	$11,000
	WAVERLEY STREET HEADWALL	80	LF	$100	$8,000
	ALMA STREET CHANNEL LINING TRANSITION	40	LF	$2,800	$112,000
					$1,626,050
	SUBTOTAL				$3,635,160
	MOBILIZATION			10%	$363,516
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$799,735
	ESTIMATED CONSTRUCTION COST				**$4,798,411**
	CONTINGENCY			25%	$1,201,589
	TOTAL FOR DESIGN AND CONSTRUCTION				**$6,000,000**

CHANNEL ALTERNATIVE

COST ESTIMATE

CSI #	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE $	TOTAL COST $
	REACH 2A - HIGHWAY 101 TO LOUIS ROAD				
	PRE-EXISTING WALL	240	LF	$35	$8,400
	MODIFIED WALL	1,560	LF	$34	$53,040
	TYPE II WALL	60	LF	$28	$1,680
	TYPE III WALL	2,400	LF	$35	$84,000
	TYPE V WALL	150	LF	$43	$6,450
	TYPE VIII WALL	190	LF	$36	$6,840
	BUTTRESS ASSEMBLY	4,320	LF	$210	$907,200
	GREER ROAD HEADWALL	120	LF	$150	$18,000
	U-FRAME CHANNEL, GREER TO LOUIS	1,060	LF	$2,800	$2,968,000
					$4,053,610
	REACH 2B - LOUIS ROAD				
	TRAFFIC CONTROL AND DETOURS	1	LS	$25,000	$25,000
	BRIDGE REPLACEMENT	1	LS	$175,000	$175,000
	UTILITY PROTECTION DURING BRIDGE CONSTRUCTION	1	LS	$100,000	$100,000
	CHANNEL MODIFICATION	120	LF	$2,800	$336,000
02.6001.041	ASPHALTIC CONCRETE, 3" ON 8" BASE, 10" SUB	27,500	SF	$5	$137,500
	ALLOWANCE FOR LOCAL SITE GRADING AND DRAINAGE	1	LS	$150,000	$150,000
					$923,500
	REACH 2C - LOUIS ROAD TO ALMA STREET				
	CHANNEL MODIFICATION	4,670	LF	$2,800	$13,076,000
	ALMA STREET CHANNEL LINING TRANSITION	40	LF	$2,800	$112,000
					$13,188,000
	SUBTOTAL				$18,165,110
	MOBILIZATION			10%	$1,816,511
	ENGINEERING, CONSTRUCTION ADMINISRATION			20%	$3,996,324
	ESTIMATED CONSTRUCTION COST				**$23,977,945**
	CONTINGENCY			25%	$6,022,055
	TOTAL FOR DESIGN AND CONSTRUCTION				**$30,000,000**

DATE: 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE: MATADERO BYPASS CHANNEL (EL=0.0, H=7.0')	BR. NO:		RCVD. BY:	IN
TYPE: CONCRETE BLOCK LINED CHANNEL	DIST:	CO:	RTE: P.M:	OUT
LENGTH 1' x WIDTH 50 = AREA 50 SQ FT				

DESIGN SECTION ____________ QUANTITIES BY __KDC__ DATE __8/27/2001__ ESTIMATE NO __10%__

PROJECT INCLUDES __1__ STRUCTURE(S) QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________

AND $ ________ ROADWORK CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	TEMPORARY SHORING	LS/LF	1.00	$238.00	$238
	STRUCTURE EXCAVATION (CHANNEL)	CY/LF	25.80	$20.00	$516
	STRUCTURE BACKFILL (CHANNEL)	CY/LF	3.60	$50.00	$180
	PRECAST CONCRETE BLOCK WALL	SF/LF	11.00	$15.65	$172
	PERVIOUS BACKFILL MATERIAL	CY/LF	5.28	$20.00	$106
	STRUCTURAL CONCRETE (CHANNEL)	CY/LF	1.70	$250.00	$425
	BAR REINFORCING STEEL	LB/LF	97	$0.60	$58

SUBTOTAL		**$1,695**
MOBILIZATION (10%)		$188
SUBTOTAL STRUCTURE ITEMS		$1,883
CONTINGENCIES (30%)		$565
BRIDGE TOTAL ($ / sq ft)	($48.97)	$2,448
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$2,448**
FOR BUDGET PURPOSES - SAY		$2,500

ROUTING

1. DESIGN SECTION ____________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS TOP OF WALL ELEVATION = 10.5

ESTIMATING - LAST
DS 93 0043

Block Wall, Conc Inv (6-8-01)
BCA.xls

DATE. 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE:	MATADERO CREEK U-CHANNEL MODIFICATION	BR. NO:		RCVD. BY:	IN	
TYPE.	REINFORCED CONCRETE CHANNEL	DIST:	CO:	RTE. P.M:	OUT	
LENGTH	x WIDTH	= AREA	0	SQ FT		

DESIGN SECTION ____________
QUANTITIES BY KDC DATE 8/27/2001 ESTIMATE NO 10%
PROJECT INCLUDES 1 STRUCTURE(S)
QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________
AND $ ________ ROADWORK
CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	TEMPORARY SHORING	LS/LF	2.00	$315.00	$630
	STRUCTURE EXCAVATION (CHANNEL)	CY/LF	10.20	$25.00	$255
	STRUCTURE BACKFILL (CHANNEL)	CY/LF	1.10	$50.00	$55
	PERVIOUS BACKFILL MATERIAL	CY/LF	2.10	$20.00	$42
	REMOVE CONCRETE (CHANNEL)	SF/LF	42.00	$5.00	$210
	REMOVE CONCRETE (FLOOD WALL)	LF/LF	2.00	$64.00	$128
	STRUCTURAL CONCRETE (CHANNEL)	CY/LF	2.60	$350.00	$910
	BAR REINFORCING STEEL	LB/LF	251.00	$0.60	$151
	DEWATERING (10%)	LS/LF	1.00	$240.00	$240

SUBTOTAL	**$2,621**
MOBILIZATION (10%)	$291
SUBTOTAL STRUCTURE ITEMS	$2,912
CONTINGENCIES (25%)	$728
BRIDGE TOTAL ($ / sq ft) #DIV/0!	$3,640
BRIDGE REMOVAL (cont. incl.) (AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES	$0
GRAND TOTAL	**$3,640**
FOR BUDGET PURPOSES - SAY	$3,700

ROUTING

1. DESIGN SECTION ________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ____________

DATE: 08/27/01
CONTRACT NO

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE:	MATADERO CREEK TEMPORARY SHORING	BR. NO:		RCVD. BY:		IN	
TYPE:	CANTILEVER SOLDIER PILE AND TIMBER LAGGING	DIST:	CO:	RTE:	P.M:	OUT	
LENGTH	x WIDTH	= AREA	0	SQ FT			

DESIGN SECTION ____________

PROJECT INCLUDE __2__ STRUCTURE(S)

AND $ ________ ROADWORK

QUANTITIES BY __MM / KDC__ DATE __8/27/2001__ ESTIMATE NO __10%__

QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________

CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	SOLDIER PILE ASSEMBLY	LS/8FT	1	$1,770.00	$1,770
	TIMBER LAGGING	MFBM/8FT	0.30	$2,370.00	$711
	NOTE: COSTS SHOWN ARE PER SIDE. RESULT SHOULD BE DOUBLED TO REFLECT TOTAL COST FOR TWO SHORING ASSEMBLIES (ONE ON EACH SIDE). ADDITIONALLY, ALL PRICES ARE SHOWN FOR AN 8-FOOT LONG SEGMENT (THE SPACING OF THE SOLDIER PILES). *SOLDIER PILE ASSEMBLY* PRICE INCLUDES THE COST OF THE CIDH PILING. EARTHWORK TO BE INCLUDED IN THE U-CHANNEL MODIFICATION ESTIMATE.				

SUBTOTAL		$2,481
MOBILIZATION (0%)		$0
SUBTOTAL STRUCTURE ITEMS		$2,481
CONTINGENCIES (0%)		$0
BRIDGE TOTAL ($ / sq ft)	#DIV/0!	$2,481
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$2,481**
FOR BUDGET PURPOSES - SAY		$2,500

ROUTING

1. DESIGN SECTION ________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS __$2,500 For 8 Foot Segment; Say $315 Per Foot__

ESTIMATING - LAST
DS 93 0043

DATE: 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE: MATADERO CREEK	BR. NO:		RCVD BY:		IN
TYPE: FLOODWALL REPLACEMENT	DIST:	CO:	RTE:	P.M:	OUT
LENGTH 1 x WIDTH 1 = AREA 1 SQ FT					

DESIGN SECTION ____________ QUANTITIES BY KDC DATE 2/8/2000 ESTIMATE NO ____________

PROJECT INCLUDES 1 STRUCTURE(S) QUANTITIES CHECKED BY ____________ DATE ____________ PRICED BY ____________

AND $ ____________ ROADWORK CHARGE UNIT AND EA ____________ COST INDEX ____________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	REMOVE CONCRETE FLOODWALL	LS/LF	1	$64.00	$64.00
	STRUCTURE EXCAVATION, RETAINING WALL	CY/LF	0.21	$65.00	$13.65
	STRUCTURE BACKFILL, RETAINING WALL	CY/LF	0.21	$55.00	$11.55
	STRUCTURAL CONCRETE, RETAINING WALL	CY/LF	0.34	$350.00	$119.00
	BAR REINFORCING STEEL, RETAINING WALL	LB/LF	35	$0.60	$21.00
	MINOR CONCRETE, CHANNEL LINING	CY/LF	0.05	$255.00	$12.75
	COSTS ARE PER FOOT OF WALL FOR A SINGLE WALL				

SUBTOTAL		**$242**
MOBILIZATION (10%)		$27
SUBTOTAL STRUCTURE ITEMS		$269
CONTINGENCIES (25%)		$67
BRIDGE TOTAL ($ / sq ft)	($336.04)	$336
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$336**
FOR BUDGET PURPOSES - SAY		$340

ROUTING

1. DESIGN SECTION ____________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ____________

ESTIMATING - LAST

DS 93 0043

DATE: 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE X

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE:	MATADERO CREEK TYPE III FLOODWALL MODIFICATION	BR. NO:		RCVD. BY:		IN	
TYPE:	FLOODWALL MODIFICATION	DIST:	CO:	RTE:	P.M:	OUT	

LENGTH 1 x WIDTH 1 = AREA 1 SQ FT

DESIGN SECTION ______
PROJECT INCLUDES 1 STRUCTURE(S)
AND $ ______ ROADWORK

QUANTITIES BY KDC DATE 9/17/1999 ESTIMATE NO ______
QUANTITIES CHECKED BY ______ DATE ______ PRICED BY ______
CHARGE UNIT AND EA ______ COST INDEX ______

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	STRUCTURAL CONCRETE	CY/SF	0.03	$350.00	$10.50
	BAR REINFORCING STEEL	LB/SF	1.34	$0.60	$0.80
	BAR REINFORCING (DOWEL)*	LB/LF	1.56	$0.60	$0.94
	DRILL AND BOND DOWEL*	LF/LF	0.50	$21.00	$10.50
	* NOTE: THIS IS A COST THAT WILL BE ASSOCIATED WITH THE LENGTH OF THE EXTENSION, NOT THE AREA OF THE EXTENSION. BE AWARE OF THIS WHEN CALCULATING TOTAL COST FOR MODIFYING AN EXISTING PORTION OF FLOODWALL.				

SUBTOTAL		$23
MOBILIZATION (10%)		$3
SUBTOTAL STRUCTURE ITEMS		$25
CONTINGENCIES (20%)		$5
BRIDGE TOTAL ($ / sq ft)	($30.32)	$30
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$30**
FOR BUDGET PURPOSES - SAY		$30

ROUTING

1. DESIGN SECTION ______
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ______

ESTIMATING - LAST
DS 93 0043

DATE 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE:	MATADERO CREEK TYPE II, V, VII FLOODWALL MOD.	BR. NO:		RCVD. BY:		IN	
TYPE.	FLOODWALL MODIFICATION	DIST:	CO:	RTE:	P.M:	OUT	

LENGTH 1 x WIDTH 1 = AREA 1 SQ FT

DESIGN SECTION ____________
PROJECT INCLUDES 1 STRUCTURE(S)
AND $ ____________ ROADWORK

QUANTITIES BY KDC DATE 9/17/1999 ESTIMATE NO ____________
QUANTITIES CHECKED BY ____________ DATE ____________ PRICED BY ____________
CHARGE UNIT AND EA ____________ COST INDEX ____________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	STRUCTURAL CONCRETE	CY/SF	0.03	$350.00	$10.50
	BAR REINFORCING STEEL	LB/SF	1.34	$0.60	$0.80
	DRILL AND BOND DOWEL*	LF/LF	0.50	$21.00	$10.50
	* NOTE: THIS IS A COST THAT WILL BE ASSOCIATED WITH THE LENGTH OF THE EXTENSION, NOT THE AREA OF THE EXTENSION. BE AWARE OF THIS WHEN CALCULATING TOTAL COST FOR MODIFYING AN EXISTING PORTION OF FLOODWALL.				

SUBTOTAL		**$22**
MOBILIZATION (10%)		$2
SUBTOTAL STRUCTURE ITEMS		$24
CONTINGENCIES (20%)		$5
BRIDGE TOTAL ($ / sq ft)	($29.07)	$29
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$29**
FOR BUDGET PURPOSES - SAY		$29

ROUTING

1. DESIGN SECTION ____________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ____________

ESTIMATING - LAST
DS 93 0043

DATE: 08/27/01
CONTRACT NO

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE: MATADERO CREEK TYPE VII FLOODWALL MODIFICATI	BR. NO:		RCVD. BY:	IN
TYPE: FLOODWALL MODIFICATION	DIST:	CO:	RTE: P.M:	OUT
LENGTH 1 x WIDTH 1 = AREA 1 SQ FT				

DESIGN SECTION ____________ QUANTITIES BY KDC DATE 9/17/1999 ESTIMATE NO ________

PROJECT INCLUDES 1 STRUCTURE(S) QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________

AND $ ________ ROADWORK CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	STRUCTURAL CONCRETE	CY/SF	0.03	$350.00	$10.15
	BAR REINFORCING STEEL	LB/SF	2.28	$0.60	$1.37
	DRILL AND BOND DOWEL*	LF/LF	1.11	$10.00	$11.10
	* NOTE: THIS IS A COST THAT WILL BE ASSOCIATED WITH THE LENGTH OF THE EXTENSION, NOT THE AREA OF THE EXTENSION. BE AWARE OF THIS WHEN CALCULATING TOTAL COST FOR MODIFYING AN EXISTING PORTION OF FLOODWALL.				

SUBTOTAL		$23
MOBILIZATION (10%)		$3
SUBTOTAL STRUCTURE ITEMS		$25
CONTINGENCIES (25%)		$6
BRIDGE TOTAL ($ / sq ft)	($31.41)	$31
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$31**
FOR BUDGET PURPOSES - SAY		$1,000

ROUTING

1. DESIGN SECTION ____________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ____________

ESTIMATING - LAST

DS 93 0043

DATE 08/27/01
CONTRACT NO

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE: MATADERO CREEK HEADWALL MODIFICATION	BR. NO:		RCVD. BY:		IN	
TYPE: HEADWALL MODIFICATION	DIST:	CO:	RTE:	P.M:	OUT	
LENGTH 1 x WIDTH 1 = AREA 1 SQ FT						

DESIGN SECTION ____________ QUANTITIES BY KDC DATE 9/17/1999 ESTIMATE NO ____________

PROJECT INCLUDES 1 STRUCTURE(S) QUANTITIES CHECKED BY ____________ DATE ____________ PRICED BY ____________

AND $ ____________ ROADWORK CHARGE UNIT AND EA ____________ COST INDEX ____________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	REMOVE BARRIER RAILING*	LS/LF	1	$35.00	$35.00
	STRUCTURAL CONCRETE	CY/SF	0.04	$350.00	$14.00
	STRUCTURAL CONCRETE*	CY/LF	0.03	$350.00	$10.50
	BAR REINFORCING STEEL	LB/SF	1.80	$0.60	$1.08
	BAR REINFORCING (DOWEL)*	LB/LF	3.90	$0.60	$2.34
	DRILL AND BOND DOWEL*	LF/LF	1.74	$21.00	$36.54
	* NOTE: THIS IS A COST THAT WILL BE ASSOCIATED WITH THE LENGTH OF THE EXTENSION, NOT THE AREA OF THE EXTENSION. BE AWARE OF THIS WHEN CALCULATING TOTAL COST FOR MODIFYING AN EXISTING PORTION OF FLOODWALL.				

SUBTOTAL		**$64**
MOBILIZATION (10%)		$7
SUBTOTAL STRUCTURE ITEMS		$72
CONTINGENCIES (20%)		$14
BRIDGE TOTAL ($ / sq ft)	($85.95)	$86
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$86**
FOR BUDGET PURPOSES - SAY		$85

ROUTING

1. DESIGN SECTION ____________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS ____________

ESTIMATING - LAST
DS 93 0043

DATE: 08/27/01
CONTRACT NO:

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE __X__

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE: MATADERO CREEK FLOODWALL MODIFICATION	BR. NO:		RCVD. BY:		IN
TYPE: BUTTRESS ASSEMBLY	DIST:	CO:	RTE:	P.M:	OUT
LENGTH x WIDTH = AREA 0 SQ FT					

DESIGN SECTION ____________

PROJECT INCLUDES __1__ STRUCTURE(S)

AND $ ________ ROADWORK

QUANTITIES BY __KDC__ DATE __8/27/2001__ ESTIMATE NO __10%__

QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________

CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	STRUCTURE EXCAVATION	CY/10FT	2	$65.00	$129
	STRUCTURE BACKFILL	CY/10FT	1	$55.00	$79
	16" CAST-IN-DRILLED-HOLE CONCRETE PILING	LF/10FT	40	$40.00	$1,600
	STRUCTURAL CONCRETE	CY/10FT	1	$350.00	$207
	BAR REINFORCING STEEL	LB/10FT	70	$0.60	$42

SUBTOTAL	**$2,056**
MOBILIZATION (10%)	$228
SUBTOTAL STRUCTURE ITEMS	$2,284
CONTINGENCIES (20%)	$457
BRIDGE TOTAL ($ / sq ft) #DIV/0!	$2,741
BRIDGE REMOVAL (cont. incl.) (AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES	$0
GRAND TOTAL	**$2,741**
FOR BUDGET PURPOSES - SAY	$2,800

ROUTING

1. DESIGN SECTION ________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

COMMENTS __BASED ON 10' O.C. SPACING__

DATE: 08/27/01
CONTRACT NO·

STATE OF CALIFORNIA - DEPARTMENT OF TRANSPORTATION

BRIDGE GENERAL PLAN ESTIMATE ______ or PLANNING ESTIMATE X

DS-D-0016 (REV 5/93)

ESTIMATING GROUP

STRUCTURE:	LOUIS ROAD BRIDGE (REPLACEMENT)	BR. NO:		RCVD. BY·	IN	
TYPE:	CIP/PS CONCRETE SLAB	DIST:	CO:	RTE:	P.M:	OUT
LENGTH 40.15	x WIDTH 62 = AREA 2,489 SQ FT					

DESIGN SECTION ____________
QUANTITIES BY KDC DATE 8/27/2001 ESTIMATE NO 10%
PROJECT INCLUDES 1 STRUCTURE(S)
QUANTITIES CHECKED BY ________ DATE ________ PRICED BY ________
AND $ ________ ROADWORK
CHARGE UNIT AND EA ________ COST INDEX ________

	CONTRACT ITEMS	UNIT	QUANTITY	PRICE	AMOUNT
	REMOVE CONCRETE (BRIDGE)	LS	1	$30,000.00	$30,000
	STRUCTURE EXCAVATION (BRIDGE)	CY	22	$125.00	$2,750
	STRUCTURE BACKFILL (BRIDGE)	CY	27	$100.00	$2,700
	PRESTRESSING, CAST-IN-PLACE CONCRETE	LS	1	$11,400.00	$11,400
	STRUCTURAL CONCRETE, BRIDGE	CY	160	$550.00	$88,000
	BAR REINFORCING STEEL	LB	35,700	$0.60	$21,420
	CONCRETE BARRIER (TYPE 26 MODIFIED)	LF	80	$200.00	$16,000
	TUBULAR HANDRAILING	LF	80	$30.00	$2,400

SUBTOTAL		**$174,670**
MOBILIZATION (10%)		$19,408
SUBTOTAL STRUCTURE ITEMS		$194,078
CONTINGENCIES (20%)		$38,816
BRIDGE TOTAL ($ / sq ft)	($93.56)	$232,893
BRIDGE REMOVAL (cont. incl.)	(AREA= sq ft)	$0
WORK BY RAILROAD OR UTILITY FORCES		$0
GRAND TOTAL		**$232,893**
FOR BUDGET PURPOSES - SAY		$233,000

ROUTING

1. DESIGN SECTION ________
2. DESIGN A SUPERVISOR
3. DESIGN B SUPERVISOR
4. PLANNING

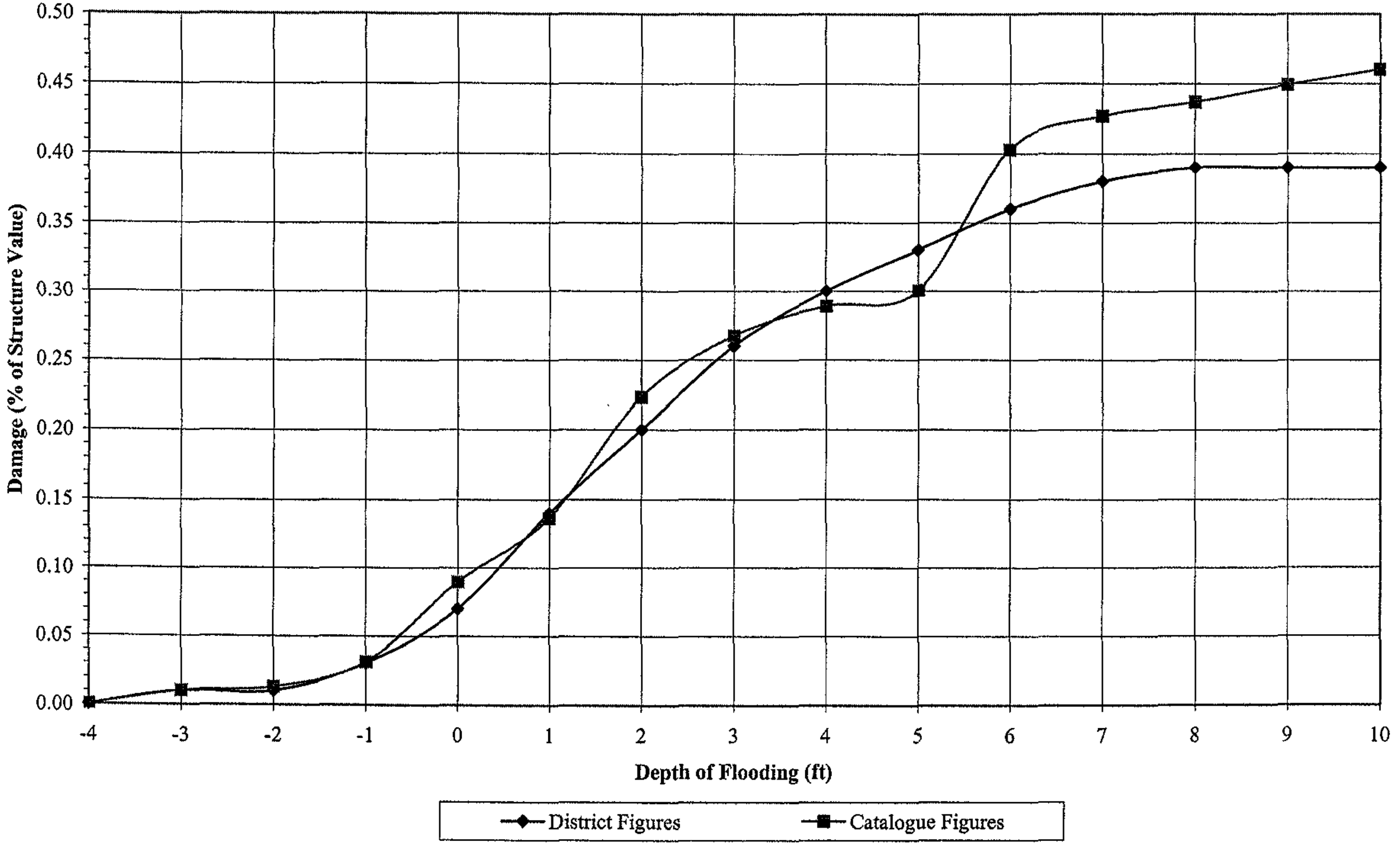
COMMENTS TEMPORARY SHORING INCLUDED IN U-FRAME WORK.
REUSING EXISTING PILES.

ESTIMATING - LAST
DS 93 0043

Land Transfers in the Vicinity of the Proposed Project for the Matadero/Barron Creeks Long-Term Remediation Project
Upstream Reservoir Alternatives

Lot Size	Transfer	Land Use	No.	Address	City	Total	Land	Structure	Other	Land Only Price Per Acre	Total Price Per Acre
Relocation of Residences Inundated by Reservoir											
1	12/2/1998	RES-SINGLE FAMILY RESIDENCE	28404	Christopher Ln	Los Altos Hills	1,130,085	508,147	621,938		508,147	1,130,085
1.01	4/2/1999	RES-SINGLE FAMILY RESIDENCE	28437	Christopher Ln	Los Altos Hills	1,224,000	918,000	306,000		908,911	1,211,881
1.01	2/29/2000	RES-SINGLE FAMILY RESIDENCE	28405	Christopher Ln	Los Altos Hills	1,291,248	727,230	564,018		720,030	1,278,463
1.02	3/20/1998	RES-SINGLE FAMILY RESIDENCE	28224	Christopher Ln	Los Altos Hills	946,230	727,230	219,000		712,971	927,676
1.07	2/5/1997	RES-SINGLE FAMILY RESIDENCE	28155	Christopher Ln	Los Altos Hills	977,623	373,613	604,010		349,171	913,666
1.1	2/25/1999	RES-SINGLE FAMILY RESIDENCE	28420	Christopher Ln	Los Altos Hills	969,000	816,000	153,000		741,818	880,909
1.31	1/3/1997	RES-SINGLE FAMILY RESIDENCE	28446	Christopher Ln	Los Altos Hills	929,865	635,806	294,059		485,348	709,821
1.2	3/3/2000	RES-SINGLE FAMILY RESIDENCE	2300	Old Page Mill Rd	Palo Alto	926,188	690,328	235,860		575,273	771,823
					Average	**$1,049,280**					
Open Space Inundated by Reservoir											
2.4	5/12/1998	FOR-FOREST AND BRUSH LANDS	27755	Central Dr	Los Altos Hills	259,724	259,724			108,218	108,218
10.9	1/28/2000	FOR-FOREST AND BRUSH LANDS	2000	Page Mill Rd	Los Altos Hills	210,912	51,400	159,512		4,716	19,350
10.95	11/1/1999	FOR-FOREST AND BRUSH LANDS	650	Los Trancos Rd	Portola Valley	159,464	63,723	95,741		5,819	14,563
2.18	4/3/2000	AGR-PASTURE-GRAZING AND RANGE LAND	25751	Elena Rd	Los Altos Hills	174,584	51,848	122,736		23,783	80,084
1.13	8/31/1998	AGR-PASTURE-GRAZING AND RANGE LAND		Roble Ridge	Palo Alto	826,620	826,620			731,522	731,522
										Average	**$190,748**
Mitigation Sites for Riparian Impact / Stanford Pasture Value											
0.25	1/28/1999	PRO-OFFICES-BANKS AND CLINICS	835	Page Mill Rd	Palo Alto	611,282	351,282	260,000		1,405,128	2,445,128
0.5	12/28/1999	PRO-OFFICES-BANKS AND CLINICS	845	Page Mill Rd	Palo Alto	1,574,667	174,667	1,400,000		349,334	3,149,334
3.13	7/9/1997	PRO-OFFICES-BANKS AND CLINICS	1500	Page Mill Rd	Palo Alto	3,818,820	348,590	3,470,230		111,371	1,220,070
5.07	7/9/1997	PRO-OFFICES-BANKS AND CLINICS	1520	Page Mill Rd	Palo Alto	5,619,278	563,400	5,055,878		111,124	1,108,339
9.86	11/1/1999	MFG-MACHINERY & ELECTRNCS-ELECTRIC	395	Page Mill Rd	Palo Alto	22,754,926	1,354,926	21,400,000		137,416	2,307,802
10.4	9/9/1998	MFG-MACHINERY & ELECTRNCS-ELECTRIC	1801	Page Mill Rd	Palo Alto	47,872,128	12,806,521	35,065,607		1,231,396	4,603,089
2.76	11/14/1997	PRO-OFFICES-BANKS AND CLINICS	2550	Hanover St	Palo Alto	11,639,049	335,811	11,303,238		121,671	4,217,047
6.16	7/1/1998	PRO-OFFICES-BANKS AND CLINICS	3175	Hanover St	Palo Alto	41,599,693	14,199,693	27,400,000		2,305,145	6,753,197
2.5	5/8/1998	PRO-OFFICES-BANKS AND CLINICS	3180	Porter Dr	Palo Alto	16,656,743	6,856,743	9,800,000		2,742,697	6,662,697
5.88	1/6/1999	MFG-MACHINERY & ELECTRNCS-ELECTRIC	3165	Porter Dr	Palo Alto	10,209,748	674,646	9,535,102		114,736	1,736,352
2.1	2/12/1999	PRO-OFFICES-BANKS AND CLINICS	3330	Hillview Ave	Palo Alto	570,289	241,091	329,198		114,805	271,566
5.66	12/3/1998	IND-MFG-RESEARCH AND DEVELOPMENT	3410	Hillview Ave	Palo Alto	11,664,720	11,628,000	36,720		2,054,417	2,060,905
5.67	1/15/1997	PRO-OFFICES-BANKS AND CLINICS	3408	Hillview Ave	Palo Alto	3,339,870	636,657	2,703,213		112,285	589,042
6.68	12/30/1997	MFG-MACHINERY & ELECTRNCS-ELECTRIC	3375	Hillview Ave	Palo Alto	35,422,509	15,583,509	19,839,000		2,332,861	5,302,771
16.2	12/30/1997	MFG-MACHINERY & ELECTRNCS-ELECTRIC	3333	Hillview Ave	Palo Alto	56,000,000	55,750,000	250,000		3,441,358	3,456,790
6.04	1/15/1997	PRO-OFFICES-BANKS AND CLINICS	3495	Deer Creek Rd	Palo Alto	5,100,015	1,163,824	3,936,191		192,686	844,373
7.25	1/15/1997	PRO-OFFICES-BANKS AND CLINICS	3495	Deer Creek Rd	Palo Alto	9,806,327	1,025,847	8,780,480		141,496	1,352,597
									Average	**$1,001,172**	

DEPTH-DAMAGE RELATIONSHIPS
Comparison of San Francisco District and Corps Catalog Figures
(for residential structure, one story, no basement)



U.S. Army Corps
DEPTH DAMAGE CHART
Northern California Urban

Depth at First Floor		1 Story W/O Basement		1 Story W/Basement		2 Story W/O Basement		2 Story W/Basement		Multi-Story Residential		1 Story Comm/Industrial		Multi-Story Comm/Industrial		Warehouse		Mobile Homes	
	Autos	Structure	Content	Structure	Content	Structure	Content	Structure	Content	Structure	Content	Structure	Content	Structure	Content	Structure	Content	Structure	Content
	0	1	2	3	4	5	6	7	8	9	10	11	12	15	16	17	18	19	20
-4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-3	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
-2	0.0000	0.0130	0.0000	0.0150	0.0000	0.0140	0.0000	0.0150	0.0000	0.0135	0.0000	0.0140	0.0000	0.0070	0.0000	0.0140	0.0000	0.0324	0.0000
-1	0.0000	0.0310	0.0000	0.0300	0.0000	0.0230	0.0000	0.0230	0.0000	0.0270	0.0000	0.0200	0.0000	0.0100	0.0000	0.0200	0.0000	0.0324	0.0000
0	0.0000	0.0897	0.1144	0.0800	0.1110	0.0540	0.0744	0.0690	0.1050	0.0705	0.0880	0.0500	0.0000	0.0200	0.0260	0.0500	0.0000	0.0844	0.1000
1	0.1250	0.1366	0.1700	0.1300	0.1350	0.0923	0.1064	0.0790	0.1260	0.1165	0.1355	0.0900	0.3000	0.0400	0.0800	0.0900	0.3000	0.4424	0.2658
1.5*	0.2915	0.1802	0.2456	0.1490	0.1460	0.1118	0.1437	0.0845	0.1355	0.1375	0.1565	0.1106	0.4710	0.0550	0.1050	0.1106	0.4710	0.5364	0.3784
2	0.4580	0.2237	0.3212	0.1680	0.1570	0.1312	0.1809	0.0900	0.1450	0.1585	0.1775	0.1311	0.6420	0.0700	0.1300	0.1311	0.6420	0.6304	0.4909
3	0.8000	0.2675	0.3449	0.1940	0.1770	0.1797	0.2262	0.1010	0.1630	0.1955	0.2180	0.1763	0.6980	0.1200	0.1800	0.1763	0.6980	0.7312	0.6407
4	0.8000	0.2888	0.3678	0.2080	0.1960	0.1995	0.2813	0.1130	0.1790	0.2280	0.2575	0.2188	0.7200	0.1500	0.2300	0.2188	0.7200	0.7829	0.7035
5	0.8000	0.3004	0.4058	0.2110	0.2130	0.2201	0.3303	0.1360	0.1950	0.2550	0.2945	0.2626	0.7340	0.1700	0.2500	0.2626	0.7340	0.7968	0.7558
6	0.8000	0.4029	0.4484	0.2110	0.2290	0.2400	0.3891	0.1490	0.2080	0.2775	0.3325	0.3078	0.7420	0.1700	0.2500	0.3078	0.7420	0.8080	0.7767
7	0.8000	0.4271	0.4984	0.2120	0.2420	0.2600	0.4340	0.1550	0.2210	0.2820	0.3685	0.3530	0.7500	0.1700	0.2500	0.3530	0.7500	0.8186	0.7880
8	0.8000	0.4371	0.5472	0.2120	0.2500	0.3000	0.4978	0.1550	0.2300	0.2820	0.3760	0.3970	0.7633	0.1700	0.2500	0.3970	0.7633	0.8186	0.8073
9	0.8000	0.4492	0.5987	0.2120	0.2500	0.3400	0.5380	0.1550	0.2500	0.2820	0.3760	0.4420	0.7750	0.1700	0.2500	0.4420	0.7750	0.8186	0.8289
10	0.8000	0.4604	0.5980	0.2120	0.2500	0.3796	0.5791	0.1550	0.2500	0.2820	0.3760	0.4875	0.7850	0.1700	0.2500	0.4875	0.7850	0.8186	0.8289
11	0.8000	0.4604	0.5980	0.2120	0.2500	0.3796	0.5791	0.1550	0.2500	0.2820	0.3760	0.4875	0.7850	0.1700	0.2500	0.4875	0.7850	0.8186	0.8289

**interpolated*

MAINTENANCE COST ESTIMATE
FOR
OVERFLOW BYPASS

Cost of ONE Cleanout			Time:	5	days
Assumptions:					
3000	CY of Sediment Removed				
600	CY/Day Removal Rate				
	Description	Unit	Quantity	Cost per Unit	Cost Per Day
	Caterpillar 938 Loader rental[1]	EA	1	$365	$365
	Dump Truck/driver rental	EA	7	$600	$4,200
	Foreman	HR	8	$66	$528
	Laborer	HR	16	$53	$848
	Equipment Operators	HR	8	$64	$512
	Disposal at BFI landfill[2]	CY	600	$20.00	$12,000
				Subtotal	$18,453
	Mobilization	LS	1	10%	$1,845
	Contingency	LS	1	20%	$4,060
				One Day Total	$24,358
			TOTAL for ONE CLEANOUT		$121,790
Source: E-mail correspondence with Tim Bramer, Eric Tsou, SDVWD, May, 2001					
[1] In case SCVWD-owned loader is not available on day of job					
[2] Kelly Graser, BFI Landfill, phone quote 4/25/01. SCVWD has $8.50/CY contract with Newby Island landfill					
Present Worth Calculation					
Cleaning Frequency (years)			4		
Annual Maintenance Costs			$30,447		
Interest			6%		
Project Life			100	years	
P/A			16.6175		
Present Worth Cost			$505,962		

MAINTENANCE COST ESTIMATE
FOR
UNDERGROUND BYPASS

Cost of ONE Cleanout			Time:	15	days
Assumptions:					
2200	CY of Sediment Removed				
150	CY/Day Removal Rate				
	2-cell box culvert with 20' wide cells for 12' bobcat turn-a-round				

	Description	Unit	Quantity	Cost per Unit	Cost Per Day
	Portable fan rental[1]	EA	5	$40	$200
	Bobcat 873 Loader rental	EA	2	$160	$320
	Caterpillar 938 Loader rental	EA	1	$365	$365
	Dump Truck rental	EA	2	$600	$1,200
	Foreman	HR	8	$66	$528
	Laborer	HR	16	$53	$848
	Equipment Operators	HR	24	$64	$1,536
	Disposal at BFI landfill[1]	CY	150	$20	$3,000
				Subtotal	$7,997
	Mobilization	LS	1	10%	$800
	Contingency	LS	1	20%	$1,759
				One Day Total	$10,556
		TOTAL for ONE CLEANOUT			$154,822

Source: 2001 Current Construction Costs, Saylor Publications, Inc.

[1] Man-hole blower fan, or 30" fan. Phone quote 4/26/01 from A Tool Shed, Santa Clara

[2] Kelly Graser, BFI Landfill, phone quote 4/25/01. SCVWD has $8.50/CY contract with Newby Island Landfill

Present Worth Calculation		
Cleaning Frequency (years)	3	
Annual Maintenance Costs	$51,607	
Interest	6%	
Project Life	100	years
P/A	16.6175	
Present Worth Cost	$857,587	

MAINTENANCE COST ESTIMATE
FOR
CHANNEL RESTORATION ALTERNATIVE

Cost of ONE Cleanout			Time:	7.5	days
Assumptions:					
1500	CY of Sediment Removed				
200	CY/Day Removal Rate				
	Description	Unit	Quantity	Cost per Unit	Cost Per Day
	Excavator rental	EA	1	$515	$515
	Dump Truck/driver rental	EA	2	$600	$1,200
	Foreman	HR	8	$66	$528
	Laborer	HR	16	$53	$848
	Equipment Operator	HR	8	$64	$512
	Disposal at BFI landfill[1]	CY	200	$20	$4,000
				Subtotal	$7,603
	Mobilization	LS	1	10%	$760
	Contingency	LS	1	20%	$3,041
				One Day Total	$11,405
		TOTAL for ONE CLEANOUT			$85,534
Source: 2001 Current Construction Costs, Saylor Publications, Inc.					
[1] Kelly Graser, BFI Landfill, phone quote 4/25/01. SCVWD has $8.50/CY contract with Newby Island Landfill.					
Present Worth Calculation					
Cleaning Frequency (years)			2		
Annual Maintenance Costs			$42,767		
Interest			6%		
Project Life			100	years	
P/A			16.6175		
Present Worth Cost			$710,681		

MAINTENANCE COST ESTIMATE
FOR
EXPANDED FLOODWAY ALTERNATIVE

Cost of ONE Cleanout			Time:	10	days	
Assumptions:						
4000	CY of Sediment Removed					
400	CY/Day Removal Rate					
	Description	Unit	Quantity	Cost per Unit	Cost Per Day	
	Excavator rental	EA	1		$0	
	Caterpillar 938 Loader rental	EA	1	$365	$365	
	Dump Truck rental	EA	4	$600	$2,400	
	Foreman	HR	8	$66	$528	
	Laborer	HR	16	$53	$848	
	Equipment Operators	HR	16	$64	$1,024	
	Disposal at BFI landfill[1]	CY	400	$20	$8,000	
				Subtotal	$13,165	
	Mobilization	LS	1	10%	$1,317	
	Contingency	LS	1	40%	$5,266	
				One Day Total	$19,748	
		TOTAL for ONE CLEANOUT			$197,475	
Source: 2001 Current Construction Costs, Saylor Publications, Inc.						
[1] Kelly Graser, BFI Landfill, phone quote 4/25/01. SCVWD has $8.50/CY contract with Newby Island Landfill.						
Present Worth Calculation						
Cleaning Frequency (years)			5			
Annual Maintenance Costs			$39,495			
Interest			6%			
Project Life			100	years		
P/A			16.6175			
Present Worth Cost			$656,310			

APPENDIX F
WATERSHED HYDROLOGY

Purpose

This watershed model provides revised Flood Insurance Study discharges on Matadero and Barron Creeks. The purpose of this hydrologic analysis is threefold:

(1) Estimate the one percent design discharge in Matadero Creek for further hydraulic analyses;

(2) Construct a working hydrologic model of the Palo Alto Flood Basin watershed that establishes design discharges at various locations of interest for Barron Creek and Matadero Creek; and

(3) Provide design inflow hydrographs into the Palo Alto Flood Basin, so that its operation may be analyzed to establish starting water surface elevations for Barron Creek and Matadero Creek.

One Percent Design Discharge Estimation

Fortunately, the United States Geologic Survey (USGS) has operated a stream gage (No. 11166000) on Matadero Creek since 1953, and a data set including 47 years of streamflow record is available. Ideally the data set used for statistical analyses of streamflow will provide a representative sample of random and homogeneous natural events, so that annual peak flow data define an unbiased estimation of future flood risk.

Within the Matadero Creek watershed as measured at its gage (see Figure F-1), events have occurred over the years that may introduce bias into the frequency analysis. These events include some increase in basin urbanization since the early 1950s (the basin is now roughly twenty percent impervious), and more importantly the institution of flow diversions from the Barron Creek watershed beginning in Fall 1996. Cumulative urbanization may tend to increase the lesser annual peaks (relative to what they would have been without urbanization), which can reduce the standard deviation and subsequent estimates for the magnitude of extreme events. Diversions into the Matadero Creek basin also skew flood frequency estimates. The Barron Creek diversion regulates measured streamflow at the Matadero Creek gage for some annual peaks, and therefore must be accounted for if those peak discharge values are to be included with the systematic record.

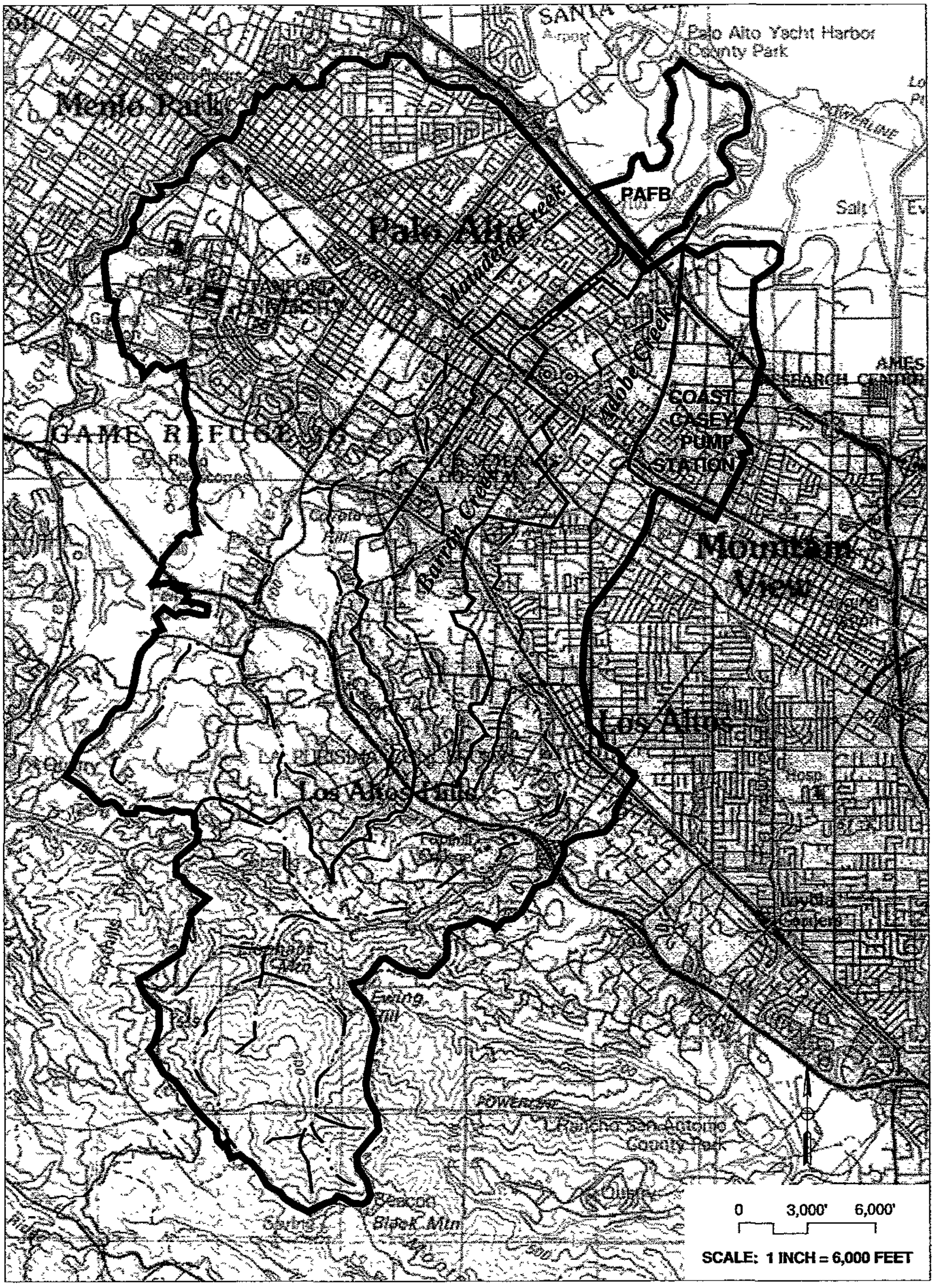


Figure F-1. Palo Alto Flood Basin Watershed

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To improve the estimate of one-percent discharge (i.e. reduce the standard error of estimate), the following procedures are used to perform a frequency analysis of recorded gage data for Matadero Creek, and provide independent checks against results from that analysis.

a. Perform a statistical analysis of gage data following the methodologies outlined in USGS Bulletin #17B (Revised September 1981).

b. Perform a similar statistical analysis of gage data for nearby San Francisquito Creek, which has 60 years of record. Since the correlation coefficient for concurrent records of annual peak discharges between Matadero Creek and San Francisquito Creek is 0.94 from 1953 to 2000, an adjustment to the frequency estimate of the short record station — Matadero Creek — is worthwhile according to Bulletin 17B.

c. Prepare a rainfall-runoff model for the watershed tributary to the Matadero Creek gage to provide an independent estimate of one-percent discharge. A design precipitation event is selected with antecedent moisture conditions calibrated for the San Francisquito Creek watershed, which is in the immediate vicinity and hydrologically similar to Matadero Creek. The San Francisquito Creek watershed has been selected for AMC calibration since its frequency estimate has a smaller standard error (longer period of record), and the watershed is primarily unurbanized.

d. Using the District's Linear Regression Model (LRM), provide another independent estimate of peak discharge at the Matadero Creek gage.

e. Evaluate and weight the independent discharge estimates based on their equivalent lengths of record.

f. Add the diversion from Barron Creek to obtain an estimate of the design discharge at the Matadero Creek gage.

g. Construct a detailed rainfall-runoff model using the District's hydrologic procedures for urbanized areas (modified as discussed herein) for the Matadero, Barron, and Adobe Creek watersheds. The calibrated rainfall pattern and antecedent moisture condition is applied, and routing parameters are adjusted to match the one percent design flow at the Matadero Creek gage.

a. Frequency Analysis of Matadero Creek Data Set. A USGS gaging station located immediately downstream of El Camino Real (and thus includes diversions from Barron Creek) has recorded stream flows since 1953 (47 years with no record in 1992 during construction). Diversions of flow into the Matadero Creek watershed beginning in September 1996 provide a significant non-homogeneity in the record, which must be adjusted accordingly. Flow diversions from Barron Creek into Matadero creek were recorded during the peak discharge events in Water Years 1998 and 2000, but not in 1997 nor 1999. While it is possible that there were no actual diversions during those years, a continuous record that could verify this does not exist, so data from 1997 and 1999 are excluded from the frequency analyses.

Matadero Creek at Palo Alto
(USGS Gage 11166000)

	Discharge (cfs)	*Water Year*
Annual Minimum	26	1954
Annual Maximum	2,560	1998
Begin Barron Diversions		1997

Recorded annual maximum discharges on February 2-3, 1998 and February 13, 2000 must be adjusted to eliminate regulated diversions from the Barron Creek watershed. Based on a physical model study of the diversion structure (CH2M-Hill, 1991), average velocity within the bypass channel during design discharge is 16 fps. Total distance from sediment basin to gage is 7,500 feet. The travel time is -

7,500 feet / 16 fps = 470 s = 7.8 min

Stage in the Barron Creek diversion basin is recorded every 30 minutes during flood events. Assume therefore, that the stage recorded at the diversion basin is roughly coincident with USGS streamflow measurements at the gage. Correcting the stream gage record to reflect undiverted flows involves subtracting Barron Creek diversions based on recorded stage in the diversion basin, using critical depth for unpressurized flow and the orifice equation when stage reaches the bottom of the steel plate at the diversion gate. Stage-Discharge relationships for the data adjustment follow.

When Stage < 83.7 Diverted Flow = 0

When 83.7 < Stage < 87.7 Critical Depth Control

$$Q_{Diverted} = b\sqrt{y_c^3\, g}$$

where b = net width of open diversion gate(s) = (No. of Gates Open)(9.79 feet)

$y_c = \frac{2}{3} E_c$

E_c = stage - 83.7

When Stage > 87.7 Orifice Control

$$Q_{Diverted} = C\, A\sqrt{2\, g\, \Delta h}$$

where C = 0.53 (ref. CH2M-Hill)

A = (4 feet)(b)

Δh = stage - 85.7 (centerline of gate)

Matadero Creek Diversion Adjustment February 2 - 3, 1998

Time	*Recorded Flow at Gage*	*Recorded Stage at Basin*	*Diversion*	*Adjusted Flow at Gage*	*Remarks*
21:30	1156	87.4	430	726	2 Gates Open
22:00	1320	87.9	494	826	
22:30	1350	86.7	314	1036	
23:00	1380	86.5	283	1097	
23:30	1410	87.0	363	1047	
24:00	2557	88.2	527	2030	
0:30	2541	88.5	279	**2262**	1 Gate Closed
1:00	2259	88.6	284	1975	
1:30	1796	88.5	279	1517	
2:00	1778	88.2	264	1514	
2:30	1566	88.0	253	1313	

Matadero Creek Diversion Adjustment February 13, 2000

Time	*Recorded Flow at Gage*	*Recorded Stage at Basin*	*Diversion*	*Adjusted Flow at Gage*	*Remarks*
16:58	1065	85.3	61	1004	1 Gate Open
17:11	1105	85.7	86	1019	
17:14	1146	85.7	86	1060	
17:53	1189	85.8	92	1097	
18:08	1271	86.1	112	1159	
18:14	1316	86.1	112	**1204**	
18:16	1271	86.1	112	1159	
18:41	1316	86.3	127	1189	
20:00	1321	86.2	120	1201	
20:10	1232	86.2	120	1112	
20:15	1189	85.5	73	1116	
21:00	1026	84.9	40	986	

Following Bulletin 17B analytical procedures for the systematic record of 1953 through 2000 (excluding 1992 and, as discussed above, 1997 and 1999), the low outlier is 23 cfs.

∴ Eliminate 1954 (26 cfs) and 1957 (28 cfs); low outlier is 40 cfs✓
∴ Eliminate 1961 (45 cfs); low outlier is 50 cfs✓
∴ Eliminate 1976 (81 cfs); low outlier is 58 cfs✗, so 1976 belongs in the data set.

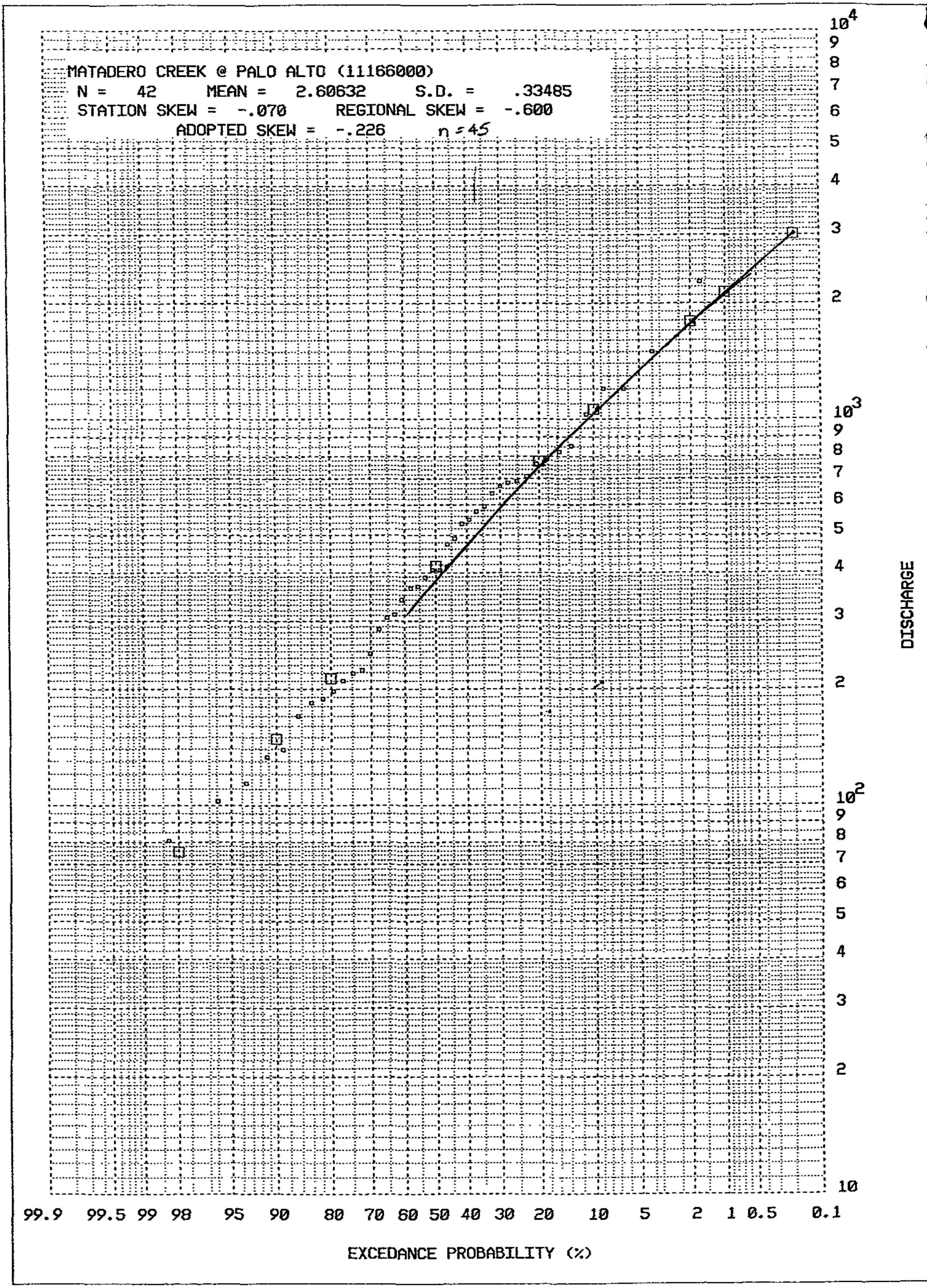
Systematic Record w/o outliers:

Mean = 2.60632
S = 0.33485
G = −0.070
G_W = −0.226 (Regional Skew = −0.6 per SCVWD, 1977)
n/N = 42/45 = .933
$Q_{1\%}$ = 2,130 cfs (Graphical Conditional Probability Adjustment - see plot)

b. Correlation w/ San Francisquito Creek Watershed. Bulletin 17B suggests that comparisons between computed frequency curves for hydrologically similar regions are useful for testing the reasonableness of flood flow frequency determinations. The centroid of San Francisquito Creek's watershed is roughly six miles from Matadero Creek's watershed centroid, so this is a natural comparison to make. The San Francisquito Creek gage began recording stream flows beginning in 1932, and provides 60 years of record with missing data from 1942 to 1950.

San Francisquito Creek at Stanford
(USGS Gage 11164500)

	Discharge (cfs)	*Water Year*
Annual Minimum	12	1961
Annual Maximum	7,200	1998


MATADERO CREEK @ PALO ALTO (11166000)
N = 42 MEAN = 2.60632 S.D. = .33485
STATION SKEW = -.070 REGIONAL SKEW = -.600
ADOPTED SKEW = -.226 n = 45
10^4
9
8
7
6
5
4
3
2
10^3
9
8
7
6
5
4
3
2
10^2
9
8
7
6
5
4
3
2
10
DISCHARGE
99.9
99.5
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.1
EXCEDANCE PROBABILITY (%)

The gage record is from 1932 to 2000 (N=60 years; no records from 1942 - 1950). Following Bulletin 17B Procedure the low outlier is 46 cfs.

Eliminate 1976 (82 cfs), 1977 (82 cfs), 1961 (12 cfs): n=56; low outlier is 135 cfs
Eliminate 1939 (120 cfs), 1957 (125 cfs): n=54; low outlier is 221 cfs✓

n/N Adjustment = 55/60 = .917

$Q_{1\%}$ = 7,700 cfs (An adjusted frequency curve is shown on the next page.)

Bulletin 17B provides a procedure for adjusting a "short" record to reflect experience at a nearby long-record station. "Short" records are defined as those less than 50 years in length, so the Matadero Creek data set qualifies. With 60 years of record, the San Francisquito Creek gage qualifies as a long-record station.

The first step of the procedure is to correlate observed peak flows for the short record with concurrent observed peak flows for the long record as follows.

Regression coefficient

$$b = \frac{\Sigma X_1 Y_1 - \dfrac{\Sigma X_1 \Sigma Y_1}{N_1}}{\Sigma X_1^2 - \dfrac{(\Sigma X_1)^2}{N_1}}$$

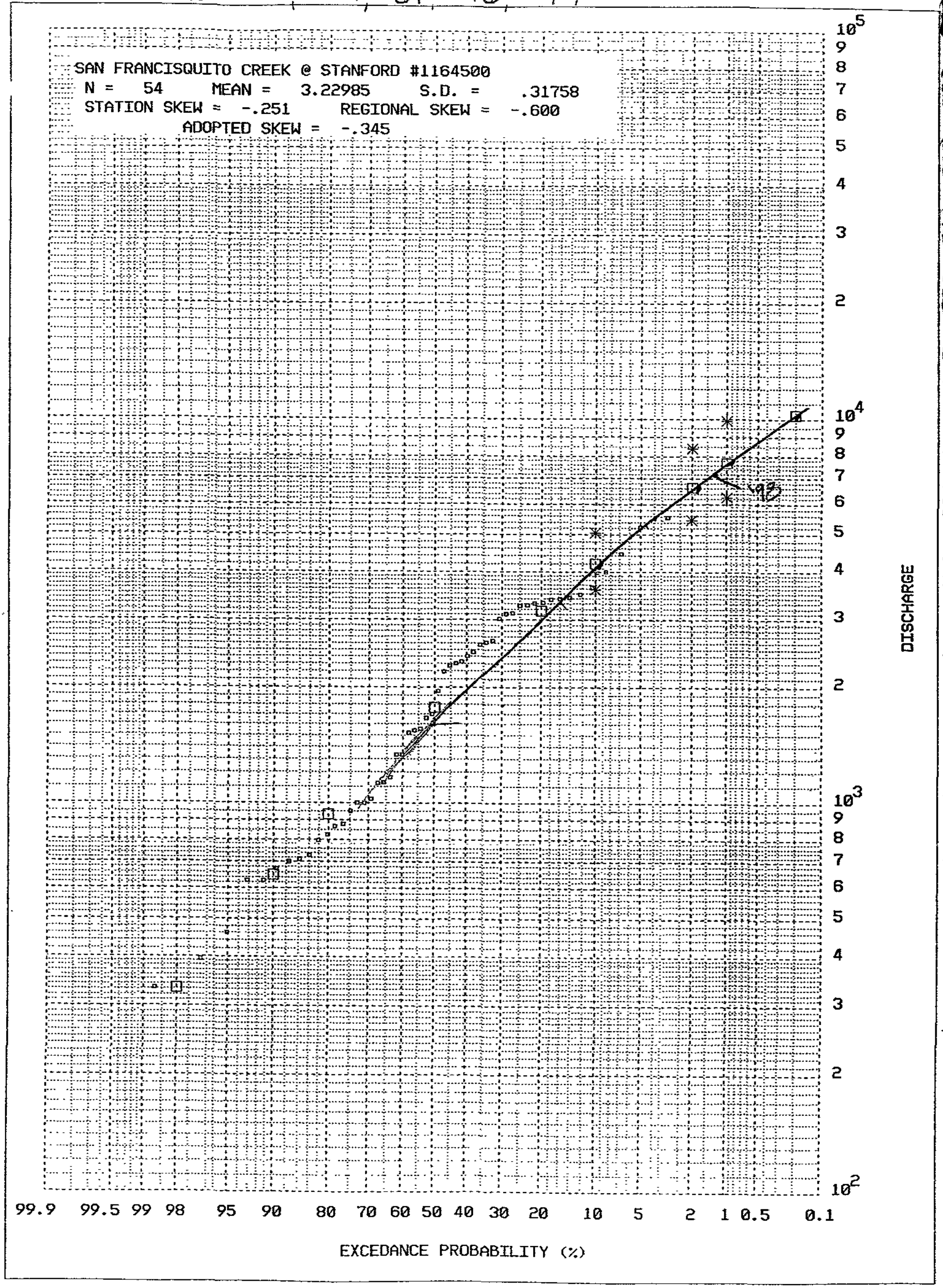
Correlation coefficient

$$r = b\,\frac{S_{X_1}}{S_{Y_1}}$$

Excluding outliers, the concurrent record includes 1953, 55, 56, 59, 60, 62-75, 78-91, 93-96, 98, 00

N_1 = Number of years flows concurrently observed at the two sites = 40
X_1 = Logarithms of flows from long record during concurrent period (mean = 3.2407)
Y_1 = Logarithms of flows from short record during concurrent period (mean =2.6374)
S = Standard deviation of logs for X and Y respectively (0.3293 and 0.3107)

Outliers '39, '57, '61, '76, '77



Using the concurrent record, $b = 0.886$

$r = 0.938$

Since there is such a strong correlation between the data sets, improved estimates of the short record mean and standard deviation can be made:

$$\overline{Y} = \overline{Y_1} + b\left(\overline{X_3} - \overline{X_1}\right)^2 = 2.6336$$

where the overbar represents the mean of logarithms and,
X_3 = Logarithms of flows for entire period at long record site (mean = 3.2365)

Adjusted variance is computed by:

$$S_y^2 = \frac{1}{(N_1 + N_2 - 1)}\left[(N_1 - 1)\,S_{y_1}^2 + (N_2 - 1)\,b^2\,S_{x_2}^2 + \frac{N_2\,(N_1 - 4)\,(N_1 - 1)}{(N_1 - 3)\,(N_1 - 2)}\,(1 - r^2)\,S_{y_1}^2 + \frac{N_1\,N_2}{N_1 + N_2}\,b^2\,(\overline{X_2} - \overline{X_1})^2\right]$$

N_2 = years when flows were observed at the longer record site but not the short record site = 15
X_2 = logarithms of flows at long record site for period with no flow record at short record site (mean = 3.2251, std. dev. = 0.2982)

$S_y = 0.3017$, which represents a 19 percent reduction in short-station variance.

According to Bulletin 17B, adjustments to the short-station mean and standard deviation are justified if the reduction in variance exceeds ten percent. The Adjusted Short-Record Frequency Estimate for Matadero Creek (G=-0.07) is therefore:

$$\log Q = 2.6336 + (2.2747)(0.3017) = 3.320$$

$$Q = 10^{3.320} = 2{,}090 \text{ cfs}$$

A conservative approach (for this particular instance) using the station skew rather than the weighted station skew has been taken. (Following the Bulletin 17B recommendation to use the weighted station skew, the estimated one-percent discharge would be 1,930 cfs.) The equivalent years of record for this adjusted estimate is found by:

$$N_e = \frac{N_1}{1 - \frac{N_2}{N_1 + N_2}\left(r^2 - \frac{(1 - r^2)}{(N_1 - 3)}\right)}$$

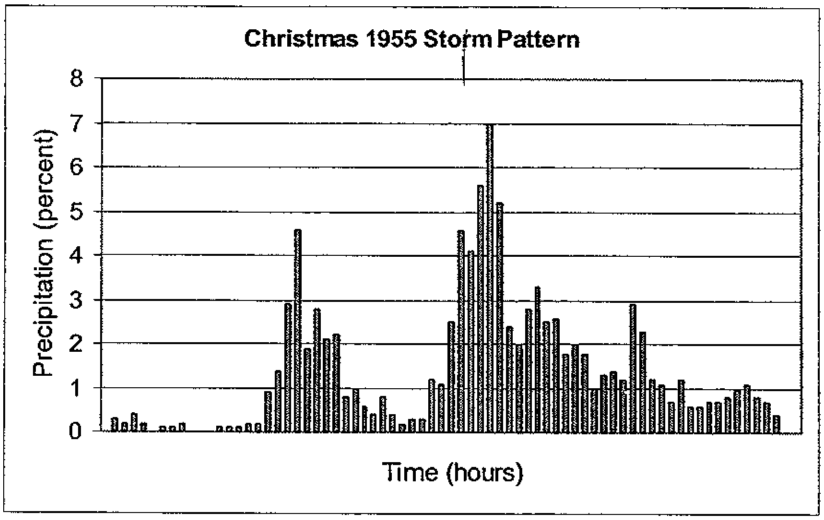
so $N_e = 53$ years

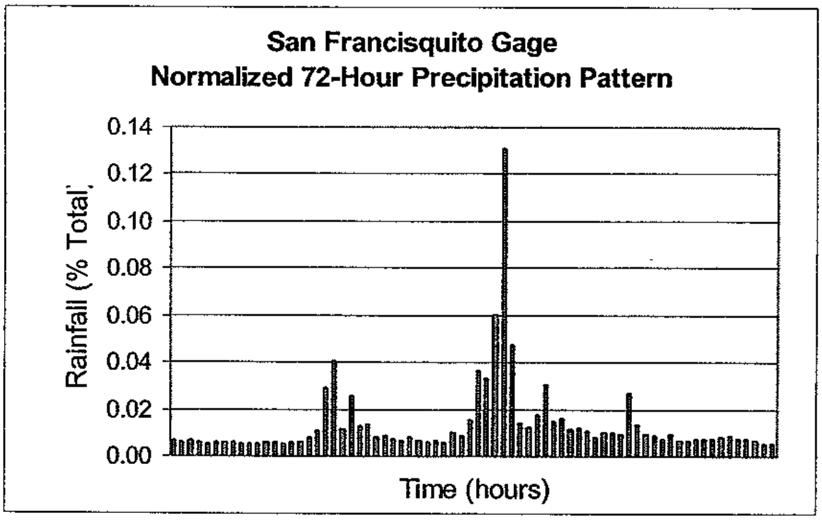
The standard error of estimate is 0.082, which represents a ten percent reduction from the short-record standard error of 0.091.

c. ***Rainfall-Runoff Model.*** Flood discharge estimates made from climatic data can provide a useful check of statistical analyses. Unit hydrograph methods are used for this purpose. To examine Palo Alto Flood Basin performance over longer periods of time, a 72-hour design storm has been selected. Precipitation depths are based on the District's "global regional equations" for obtaining design storms at ungaged basins. The precipitation pattern is from the Christmas 1955 three day storm for northern California (see distribution below), adjusted using the global regional equations to preserve local statistics. That is, during the peak one-, two-, three-, six-, 12, and 24-hours, precipitation depths will match local depth-duration-frequency statistics.

This approach allows the precipitation pattern to be calibrated to stream gage frequency analyses by matching antecedent moisture conditions. Ratios of shorter duration precipitation depth to the 72-hour depth duration are assumed to remain fairly constant throughout the watershed. The 72-hour statistically balanced precipitation pattern (percent total vs. time) is also presented below.

The selection of a 72-hour storm pattern rather than the District standard of 24 hours does not impact estimates of peak discharge because the precipitation pattern has been balanced. A three day storm duration has been arbitrarily selected for volumetric analysis because this is the duration of the District's design storm for Northern California.





Antecedent moisture conditions (AMC) are calibrated to the San Francisquito Creek frequency analysis for three primary reasons:

(1) San Francisquito Creek has a longer period of record and therefore its standard error of estimate is lower than that of Matadero Creek;

(2) The San Francisquito Creek watershed is mostly unurbanized; and

(3) Calibrating AMC to the San Francisquito Creek gage instead of the Matadero Creek gage provides a more independent estimate of discharge.

A description of model calibration follows.

San Francisquito Creek at USGS Gaging Station

Area = 37 mi^2
Undeveloped SCS Curve No. 68 (AMC II) - See CLOMR Submittal for CN development
Percent Impervious = 5
Mean Annual Precipitation = 32 inches
One percent, 72-hour Depth = 10.93 inches

This basin is not urbanized, so use Corps of Engineers Equation for Basin Lag -

$$t_{lag} = 24\, n \left(\frac{L\, L_c}{\sqrt{S}} \right)^{0.38}$$

Because of the way the Corps defines basin lag, this result is multiplied by 0.862 to be consistent with unit hydrograph definitions used by the SCS. Based on observation, using the Corps lag equation along with its S-Graph for the San Francisco District, generally replicates synthetic unit hydrographs produced by Clark parameters in HEC-1, when the time of concentration equals the adjusted time to peak.

Basin "n" = 0.08 (COE parameter)
L = 63,800 feet = 12.08 mi
L_C = 28,000 feet = 5.30 mi
S = 0.016 = 84 ft/mi

$$t_c = (0.862)\, 24\, n \left(\frac{L\, L_c}{\sqrt{S}} \right)^{0.38} = 3.48\ hours$$

R Values. SCVWD hydrology procedures provide a range of R values (storage coefficient), so that the ratio of R to the sum of R and t_c is between 0.5 and 0.9 for rural areas. Since the shape of the unit hydrograph is so sensitive to the selection of R, additional work has been done to evaluate the relationship between R and $t_{c.}$

The San Francisco Corps of Engineers S-Graph has been used to establish a unit hydrograph for the San Francisquito Creek basin at the Stanford gage. Clark's unit hydrograph is then manipulated to replicate results by varying R according to basin "n" for the same curve number. As the following table indicates, the ratio of R to t_c does not vary as long as the time of concentration is allowed to vary with "n" for unurbanized basins.

n	t_{lag}	t_c	Q_{peak}	R	$R/(R+t_c)$
0.100	5.0	4.3	6830	5.0	0.54
0.075	3.8	3.3	8130	3.8	0.54
0.050	2.5	2.2	10200	2.5	0.54

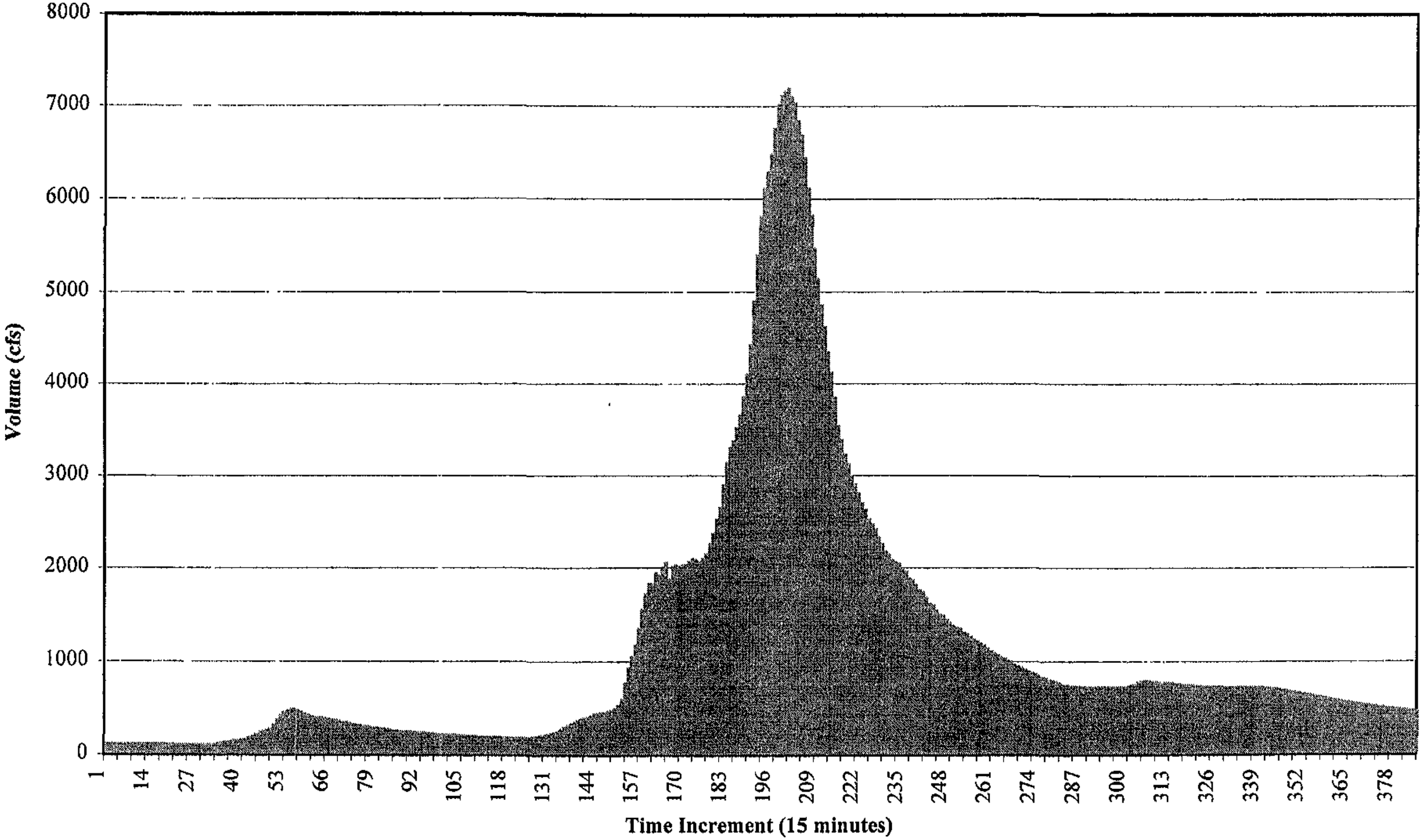
Base Flow Recession. Recession constants for an exponential recession curve have been estimated using the actual February 1998 hydrograph at the gage. (See Figure F-2 for hydrograph separation.) Base flow starts at about 480 cfs (or 13 cfs per square mile); the recession begins at 3,395 cfs (0.48 times the peak discharge), and has an exponential coefficient of 1.13 based on an analysis of the recession limb of the hydrograph.

Results of Gage Calibration

Curve Number = 59 (AMC 1.55; use I½)
Peak Flow = 7,696 cfs ($Q_{1\%}$ = 7,700 cfs)

A separately bound Conditional Letter of Map Revision application for the Matadero/Barron Creeks Remediation Project has more information regarding San Francisquito Creek watershed parameters, unit hydrographs, and the HEC-1 rainfall-runoff model.

Figure F-2. SAN FRANCISQUITO CREEK @ Stanford Gage
96 Hour Hydrograph
February 1, (12:15 a.m.) to February 4, (12:00 p.m.) 1998



Calibrated Model of Matadero Creek Watershed

Using the Calibrated Rainfall Pattern, with AMC I½ for Matadero Creek:

Matadero Creek at USGS Gaging Station

Area = 7.5 mi^2
Undeveloped SCS Curve No. 68 (AMC I½) - See CLOMR Submittal
Percent Impervious = 20
Mean Annual Precipitation = 24.7 inches
One percent, 72-hour Depth = 8.53 inches

Use Corps of Engineers Equation for Basin Lag -

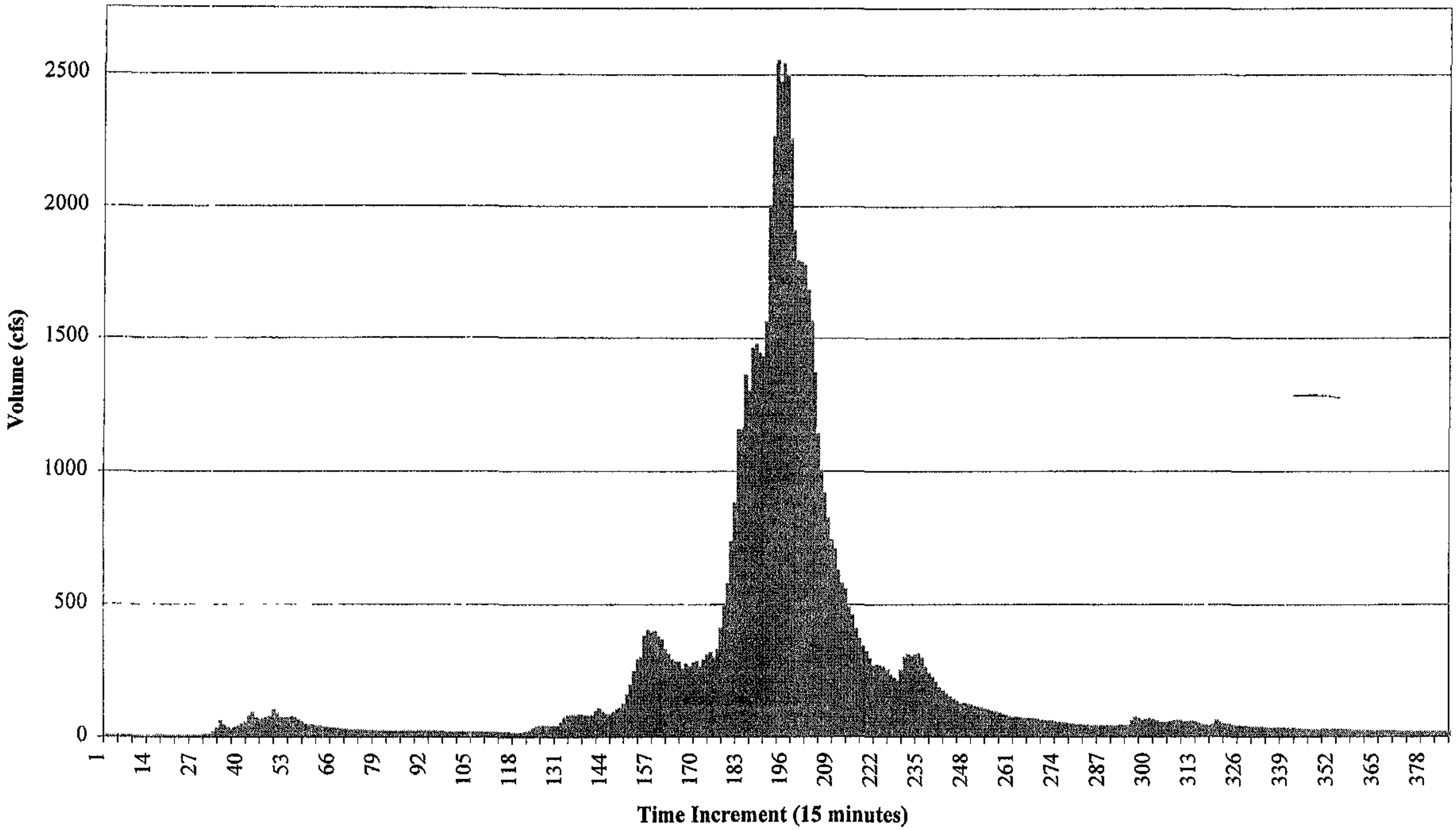
$$t_{lag} = 24\ n \left(\frac{L\ L_c}{\sqrt{S}} \right)^{0.38}$$

Weighted Basin "n" = 0.058 (COE parameter, see CLOMR Submittal)
L = 31,200 feet = 5.91 mi
L_C = 17,000 feet = 3.22 mi
S = 0.015 = 79 ft/mi

$$t_c = (0.862)\ 24\ n \left(\frac{L\ L_c}{\sqrt{S}} \right)^{0.38} = 1.60\ hours$$

Base Flow Recession. Recession constants for an exponential recession curve have been estimated using the actual February 1998 hydrograph at the gage (see Figure F-3 for hydrograph separation). Base flow starts at about 60 cfs (or roughly 8 cfs per square mile); the recession begins at 1,007 cfs (0.5 times the peak discharge when adjusted for diversion), and has an exponential coefficient of 1.4 based on an analysis of the recession limb of the hydrograph.

Figure F-3. MATADERO CREEK @ El Camino Gage
96 Hour Hydrograph
February 1, (12:15 a.m.) to February 4, (12:00 p.m.), 1998



Results of Rainfall-Runoff Modeling

Peak Flow = 2,200 cfs

According to Bulletin 17B, in the absence of an accuracy appraisal, an equivalent record length of ten years should be used for such estimates.

d. LRM Regression Analysis at Matadero Creek Gage

Following guidelines published in the District Hydrology Procedures Manual (SCVWD, 1996):

A = 7.5 mi^2
M.A.P. = 24.7 in
S = 0.015

a_0 = 0.3931
a_1 = 0.8811
a_2 = 1.279
a_3 = -0.09636
σ_e = 0.264 (Equivalent to standard error of estimate)

LRM Equation:

$$\hat{Q} = 10^{a_0} A^{a_1} MAP^{a_2} S^{a_3} \exp[2.3026\, M_e + 2.65 SD_e^2] = 1{,}590\ cfs$$

Estimate Equivalent Years of Record for LRM

Per District, standard error of regression is 0.264
Determine 68.3% (±1σ) Confidence Limit using 17B:

$$U_{p,c} = \bar{X} + S\left(K_{p,c}^{U}\right) \qquad L_{p,c} = \bar{X} + S\left(K_{p,c}^{L}\right)$$

$$U_{p,c} - L_{p,c} = S\left(K_{p,c}^{U} - K_{p,c}^{L}\right)$$

$$\left(K^{U}_{p,c} - K^{L}_{p,c}\right) = \frac{(2)(0.264)}{0.33} = 1.60$$

$$K^{U}_{p,c} = \frac{K_{\tilde{G},p} + \sqrt{K^{2}_{\tilde{G},p} - ab}}{a} \qquad K^{L}_{p,c} = \frac{K_{\tilde{G},p} - \sqrt{K^{2}_{\tilde{G},p} - ab}}{a}$$

$$a = 1 - \frac{z_c^{2}}{2\,(N - 1)} \qquad b = K^{2}_{\tilde{G},p} - \frac{z_c^{2}}{N}$$

S = .33 (Assumed per Gage Analysis)
G_W = -.6 per SCVWD
$K_{-.6,1\%} = 1.88$; $K^{2}_{-.6,1\%} = 3.53$
$z_c\ (1 - \alpha/2 = 0.842) = 1.024$

Trial & Error

N	a	b	K^U	K^L	$K^U - K^L$	
4	0.825	3.268	3.39	1.17	2.22	X
6	0.895	3.355	2.91	1.29	1.62	✓
7	0.913	3.38	2.79	1.33	1.46	X

∴ This regression is equivalent to about 6 years of record based on its standard error.

e. Weighting of Estimates. Independent estimates of peak discharge are weighted per Bulletin 17B, which proscribes the use of a ten year record length in the absence of an accuracy appraisal for any particular estimate, such as the rainfall-runoff model estimate. Since the long-record correlation has reduced the variance of estimate, but is *not* independent of the Matadero frequency analysis, only the extended data estimate ($N_e = 53$ years) is used to weight discharges. Also, it is felt that by excluding the 1998 flood of record within the District's LRM regression (due only to the timing of the regression analysis itself), the LRM estimate should not be weighted.

$$Q = \frac{(53)\ (2{,}090\ cfs)\ +\ (10)\ (2{,}200\ cfs)}{53\ +\ 10} = 2{,}107\ cfs$$

A rounded discharge estimate of **2,100 cfs** is used for design, with an equivalent record length equal to the sum of the record lengths of each estimate, or 53 + 10 = 63 years.

f. Add Diversion to Obtain Design Flowrates. Based on the calibrated watershed model (which is adjusted to match the design flowrate at the Matadero Creek gage), the one percent design discharge at the Barron Creek diversion is 740 cfs. At this discharge, the diversion is 580 cfs according to the discharge-elevation curve in CH2M-Hill's design report. The calibrated watershed model also shows a local peak addition of roughly 120 cfs at Alma Street. Therefore the recommended design flowrates in Matadero Creek downstream of the Southern Pacific Railroad (now Union Pacific Railroad) rounded to two significant figures are:

Matadero Creek Discharge	2,100 cfs
Barron Creek Diversion	580 cfs
Discharge at El Camino Real	**2,700 cfs**
Local Runoff	120 cfs
Discharge at SPRR	**2,800 cfs**
Capacity of Matadero Pump Station	275 cfs
Discharge at Highway 101	**3,100 cfs**

During a one-percent runoff event, water surface elevations in Matadero Creek preclude the addition of local runoff downstream of Alma Street (SPRR). Local runoff moves parallel to the creek, and is eventually pumped into the creek just upstream of Highway 101 by the Matadero Pump Station.

g. Detailed Hydrologic Model of PAFB Watershed. The CLOMR Application on file with the District describes the development of a detailed watershed model for use in estimating long-duration inflow into the flood basin, and discharge values for Barron Creek. This model has been built using the District's urban area hydrology procedures with the following modifications and additions:

(1) The model is calibrated to a weighted estimate based on streamflow gage records (n=63) rather than to the LRM model (n=6).

(2) Rural times of concentration are based on the Corps' lag equation adjusted for use with the Clark synthetic unit hydrograph as discussed previously.

(3) A rural condition curve number is used with the percent impervious area superimposed, using District equations for initial times of concentration. Urban times of concentration are calculated using hydraulic lengths along the main stem, average basin slope along the main stem, and gutter flow velocities.

(5) Muskingum routing procedures are used to lag and attenuate rural area hydrographs. Muskingum-Cunge routing techniques are used in urbanized channels.

A full description of watershed model development may be found in the separately bound Matadero/Barron Creek Remediation Project CLOMR Application. (Schaaf & Wheeler, 2001)

APPENDIX G
PALO ALTO FLOOD BASIN OPERATION

INTRODUCTION

The Palo Alto Flood Basin (PAFB) was created in 1956 with the construction of levees surrounding a 600-acre portion of the Palo Alto Baylands. Land upon which the flood basin sits is owned by the City of Palo Alto. The Santa Clara Valley Water District (District) has maintenance easements for flood control facilities (levees and 15 of 16 tide gates) that make up the flood control component of this facility. The City of Palo Alto is responsible for the other tide gate, which is also equipped as a motorized sluice gate that can be opened to allow two-way circulation between San Francisco Bay and the wetland marsh of the basin.

This appendix provides a comprehensive evaluation of the entire hydrologic system associated with the Palo Alto Flood Basin to not only update studies conducted over twenty years ago, but also to incorporate the PAFB's present-day operational characteristics into the starting water surface elevations for Barron Creek and Matadero Creek.

PALO ALTO FLOOD BASIN OPERATION

Figure G-1 shows an April 1999 aerial photograph of the PAFB. The basin extends east-northeast from Highway 101 and receives inflow from Matadero Creek, Adobe Creek, Barron Creek, and the Coast Casey Stormwater Pumping Station. Inflow is stored in the PAFB and released to San Francisco Bay through a tide gate structure. This structure consists of 16 box culverts (each 5 ft. by 5 ft. in dimension) with flap gates at each downstream face. These flap gates open when the stage in the PAFB is higher than the San Francisco Bay tide heights. The gates close when the tide rises to prevent Bay waters from entering the PAFB, thereby maintaining available volume for holding creek runoff during high-flow events. During summer months, the City of Palo Alto opens one of the tide gates to allow circulation of seawater in the PAFB. All of the tide gates have an invert elevation of -5.1 ft. NGVD.

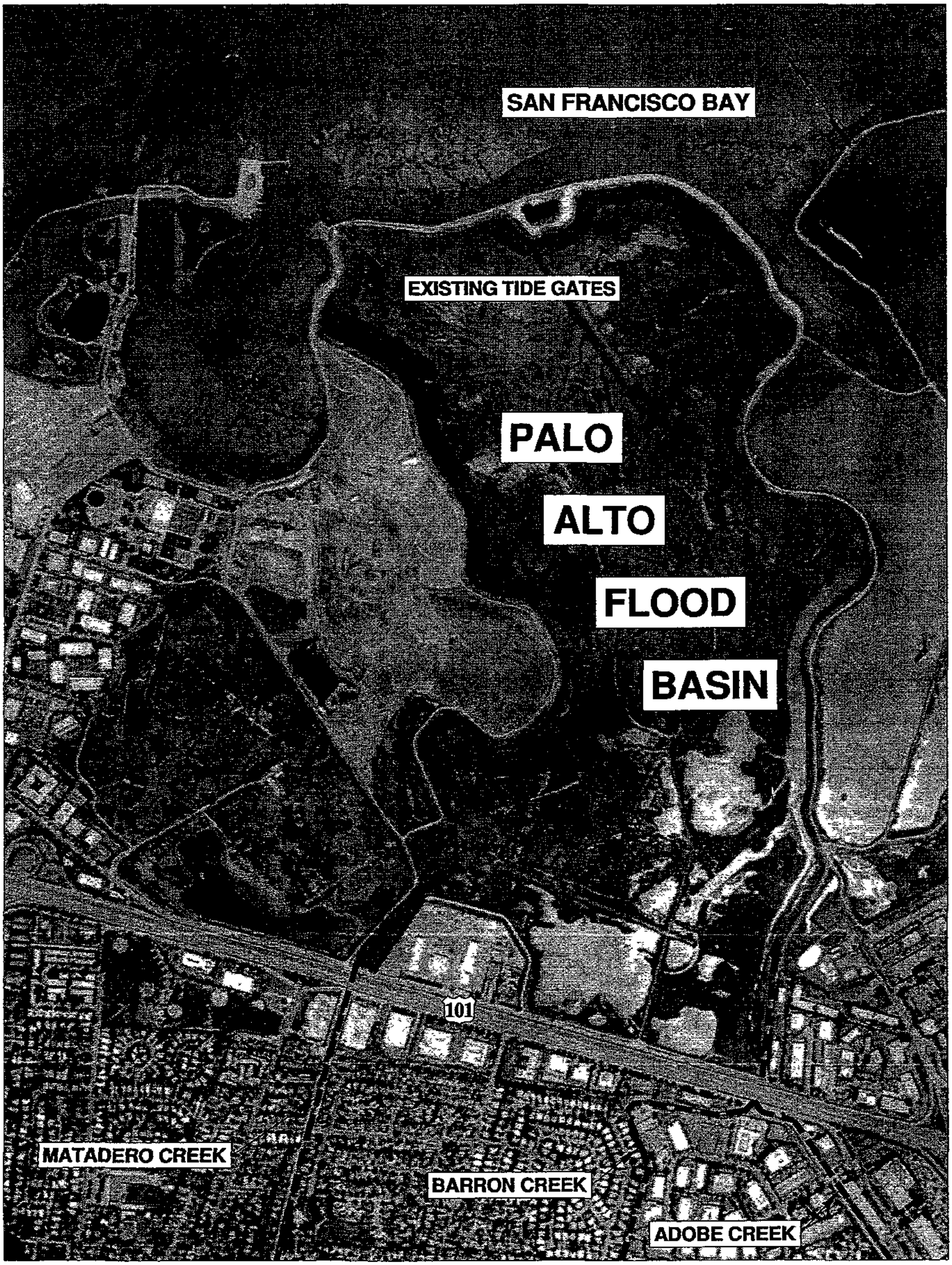


Figure G-1. Palo Alto Flood Basin

Aerial Photo by Towill Engineers, April 1999

Elements of the Palo Alto Flood Basin Analysis

The primary objective of this analysis is to determine an appropriate downstream water surface elevation for hydraulic modeling of Barron and Matadero Creeks for the one-percent base flood event. Several factors within and outside of the PAFB could impact this elevation:

- Influence of Tides on Tide Gate Discharge Capacity The height and timing of tides in San Francisco Bay impact the filling and draining of the PAFB. Inadequate discharge capacity during high inflow events could increase design water levels in the PAFB.

- Storm Duration and PAFB Stage In earlier studies, the District's design hydrograph for the PAFB watershed was based on a 24-hour storm. For analyzing extreme events, longer duration storms (such as 72 hours) provide more conservative estimates of total runoff volume. This, in turn, can affect the water surface in the PAFB, especially if discharges to the Bay are limited by tidal activity.

- Starting Water Surface Elevation in PAFB If back-to-back storms occur, the level of the PAFB at the time that inflows from the second storm reach the basin could impact water surface elevations in the creeks. To simulate this, a 3-day storm was used for analysis, with the 24-hour storm occurring on the second day.

- Sedimentation For design, it is necessary to determine whether the storage capacity of the PAFB has decreased over time by sediment deposits from freshwater inflows. Reduced capacity could raise basin water levels and impact water surface elevations in the creeks.

Tidal Influence from San Francisco Bay

As described earlier, the PAFB stores runoff from several creeks in Palo Alto and discharges the runoff to San Francisco Bay via tide gates. The gates were constructed to prevent Bay tides from filling the PAFB and to discharge stored runoff from the basin during ebb (low) tides. The height and timing of tides during storm events may play a crucial role in the filling and draining of the PAFB and impact the extent and duration of peak water elevations in the basin.

Average Tides The U.S. Army Corps of Engineers has established a *19-year mean tide cycle* for San Francisco Bay and other geographical locations on the West Coast. This cycle represents average tide heights over a specific period known as the tidal epoch, which spans the 19 years it takes for every possible combination of relative positions for the sun, moon and earth to occur. A mixed tide cycle predominates on the West Coast of the United States. This cycle consists of two high tides (one higher than the other) and two low tides (one lower than the other) each lunar day. The tide cycle points are known as high-high (HH), high (H), low (L) and low-low (LL).

Based on calculations for these relative celestial positions, it is possible to predict tides for any day of the year at any time of the day. *Astronomic tides,* created by the gravitational forces of the moon and sun acting on earth's oceans, are provided in tide prediction calendars. The mean tide cycle is simply the long-term average of astronomic tides. *Observed tides*, on the other hand, are actual tidal elevations recorded by National Oceanic and Atmospheric Administration (NOAA) gaging stations located throughout coastal areas. Table G-1 provides the extreme points of the Corps of Engineers' 19-year metonic cycle for the current tidal epoch. Tide elevations are presented on the 1929 National Geodetic Vertical Datum (NGVD) at the Palo Alto Yacht Harbor which is located adjacent to the tide gate discharge. Traditionally, Mean Higher High Water (MHHW) is used as the starting water surface elevation where riverine (freshwater) runoff meets an estuarine (saltwater) body.

Table G-1
USACE Mean Tide Cycle at Palo Alto Yacht Harbor
(All elevations in feet NGVD)

Tide	*19-year Mean*
Higher High	4.2
High	3.1
Low	-1.7
Lower Low	-4.0

Historical Tide Data Analysis The El Niño storm of February 2-3, 1998 provided an ideal event for examining potential correlations between runoff events and tide action. While stream runoff as measured by the Matadero Creek and San Francisquito Creek gages was at historic recorded levels, observed tides in San Francisco Bay were substantially higher than predicted. Figure G-2 shows the predicted and recorded tides for this date at NOAA's Golden Gate gaging station, located at the Presidio of San Francisco. Recorded tides during this runoff event were consistently higher (on the order of 2 feet) than the astronomic (predicted) tide heights. As a control, observed tide heights are compared to predicted tides for July 1998 at the same station, using the same sets of data. Figure G-3 shows tide elevations for July 11-12, 1998, when there is very close agreement between the predicted and the actual tides.

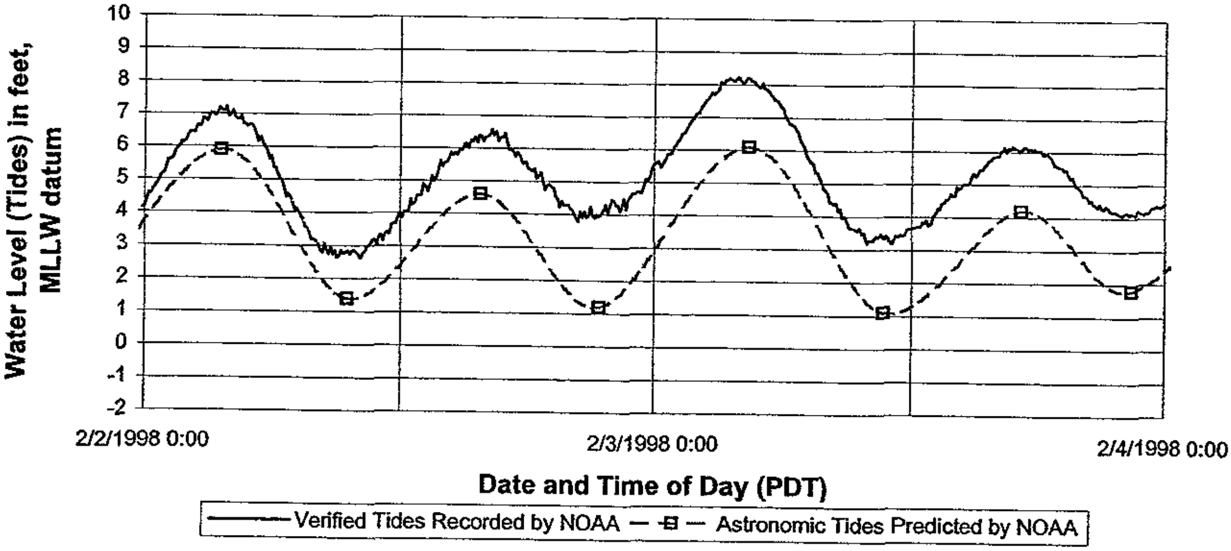


Figure G-2. February 2-3, 1998 Tide Data
NOAA Golden Gate Station

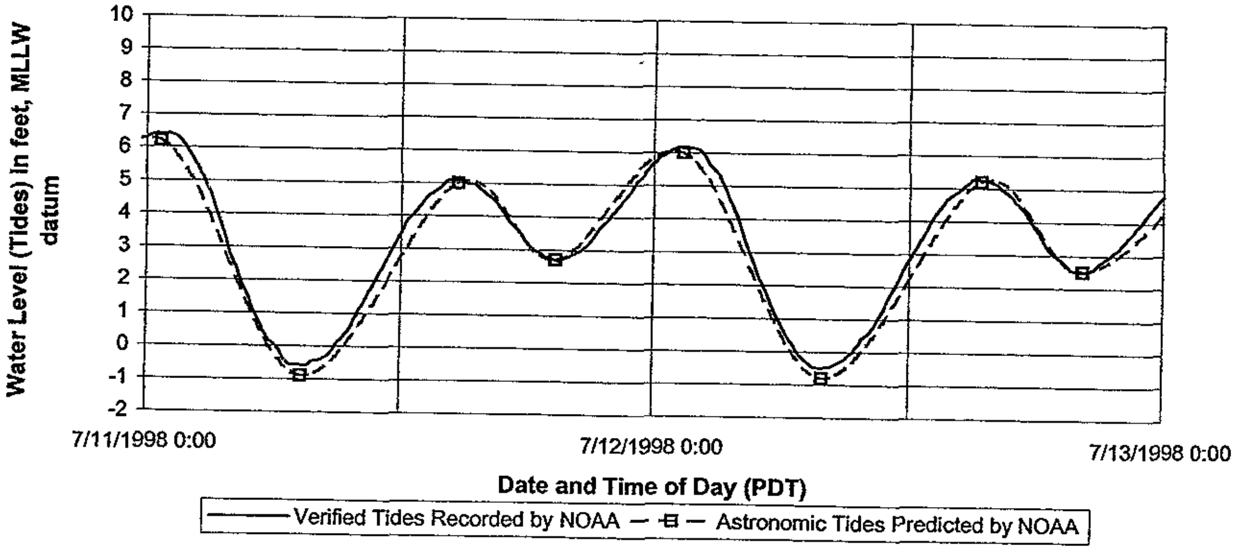


Figure G-3. July 11-12, 1998 Tide Data
NOAA Golden Gate Station

The observations presented by Figures G-2 and G-3 lead to the conclusion that further investigation into the potential for higher tides during heavy periods of stream runoff is indeed warranted. Consequently, historic tide records have been examined to see whether the phenomenon demonstrated in February 1998 at the Presidio have occurred elsewhere in the Bay Area or during other heavy runoff events in the past. Results of this investigation presented in Table G-2 indicate that during the 1998 runoff event, similar rises in tide elevations (over astronomic) were experienced at other recording tide stations in the Bay.

Table G-2
Comparison of Observed Tide Elevations with Predicted Tides During February 1998 Storm Event

Location	*Maximum Difference Between Predicted and Recorded Tides in feet*	
	Higher High	*Lower Low*
Golden Gate	2.0	2.9
Alameda	2.0	2.7
Redwood City	2.0	2.7
Monterey Harbor	1.7	1.8

The observed phenomenon presented in Table G-2 is not strongly dependent upon tide gage location, particularly within San Francisco Bay. For an examination of past history, data is available for the Golden Gate tide station beginning in 1854. Historic data for other tide stations within San Francisco Bay is not as readily available; however, recorded tide heights at the Golden Gate may be readily transposed to other locations within San Francisco Bay. The Presidio gage has the longest record of continuous tidal measurements in the United States, and "extreme high tides in the South Bay can be extrapolated from Presidio tide gage records." (USACE, 1988) Figure 4-4 compares the observed February 1998 tide at the Golden Gate transposed to Redwood City using the Corps of Engineers' translation parameters (time and elevation), against the observed tide at Redwood City, which is the closest NOAA recording gage to the outlet of the Palo Alto Flood Basin.

To examine historic tides during heavy runoff periods, the ten highest runoff events at the San Francisquito Creek gage since 1932 have been identified, along with coincident tidal patterns during those runoff events.

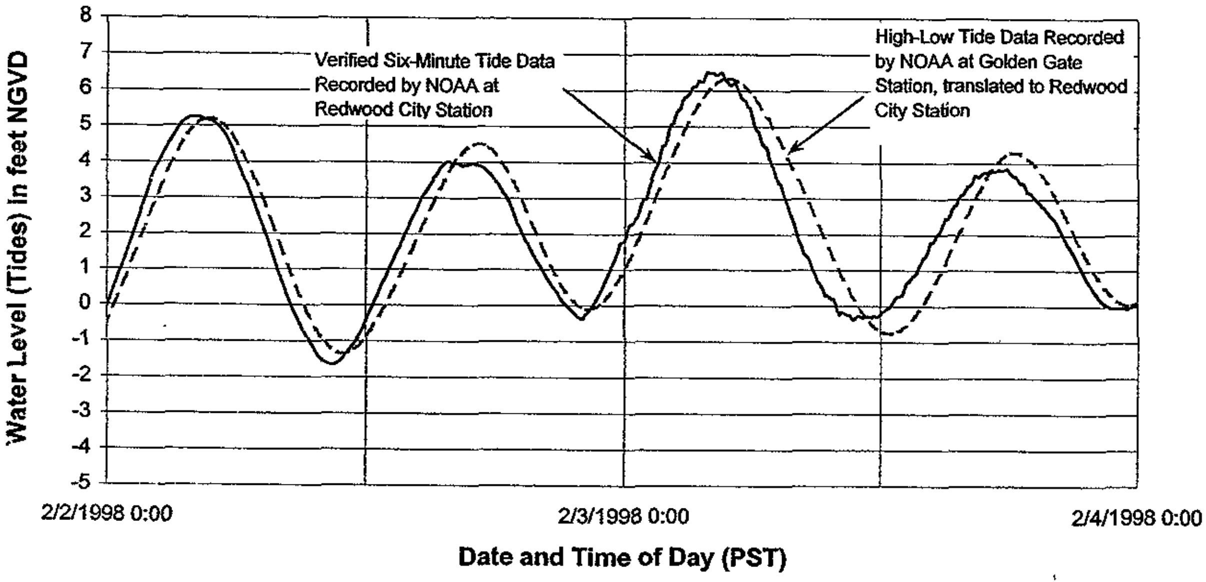


Figure G-4. February 2-3, 1998 Tide Data
NOAA Redwood City Station

Table G-3 presents differences between observed tides and predicted tides during the ten greatest runoff events recorded at the San Francisquito Creek gage. The month and year of each storm event are listed, followed by the accompanying peak flowrate on San Francisquito Creek and the annual return period for that storm. The tides are those that occurred within 24 hours of the peak runoff during the storm event.

Data indicate that higher tides as observed during the February 1998 event are not an isolated incident; rather, higher than predicted tides can be expected during storm events that generate significant runoff. Increases in the data set between observed tides over predicted tides range from 0.3 foot to 2.0 feet for the higher high tide, and from 0.9 foot to 3.0 feet for the lower low tide.

From observed historical data, it appears that storm-related forces induce higher tides during rainfall events, and by extension, runoff events. This phenomenon may be due to a number of meteorological or hydrologic factors. NOAA refers to the term "inverse barometer effect", and defines it as higher tides that are caused by lower barometric pressures associated with winter storm systems. References to "storm surges", whereby the meteorological effects of low barometric pressures and/or strong southerly winds are also found in the literature.

Table G-3
Comparison of Difference between Actual and Predicted Tide Heights
(feet MLLW at Golden Gate)
for Ten Largest Runoff Events on San Francisquito Creek (1932-2000)

			Actual (A) and Predicted (P) Tides					
			Higher High			Lower Low		
Date	Discharge (cfs)	Return Period (Years)	A	P	Δ	A	P	Δ
2/03/98	7,200	75	8.2	6.2	2.0	3.9	1.0	2.9
12/22/55	5,560	25	5.8	5.5	0.3	2.0	1.1	0.9
1/04/82	5,220	21	7.1	6.1	1.0	2.5	0.3	2.2
4/02/58	4,460	13	7.0	5.9	1.1	1.4	-0.1	1.5
1/21/67	4,000	10	6.8	6.2	0.6	1.6	0.1	1.5
2/13/00	3,930	9	6.7	6.1	0.6	1.5	0.3	1.2
2/16/82	3,760	8	7.1	6.1	1.0	2.5	0.3	2.2
11/18/50	3,650	8	5.7	5.4	0.3	0.7	-0.1	0.8
2/17/86	3,480	7	6.2	5.6	0.6	2.4	0.9	1.5
1/26/83	3,420	7	8.7	7.0	1.7	1.6	-1.4	3.0

The exact nature and cause of this phenomenon, however, are not as important as potential impacts to the PAFB operation and starting water surface elevations. Figure G-5 shows the correlation between historic coincident high tides and the maximum annual runoff for San Francisquito Creek over 59 years of concurrent records. (Tide data for the 1978 maximum discharge event are not available.) A similar correlation for lower low tides is shown in Figure G-6. Linear regression using the least squares method suggests that design tide elevations should be adjusted upward.

Desired system reliability governs the selection of an appropriate tidal cycle for design. The risk-based analysis of required freeboard for Matadero Creek between Highway 101 and Alma Street (Appendix I) is predicated upon a starting water surface elevation in the PAFB with a reliability of 99 percent. In other words, the probability of exceedance is limited to one percent. (Using the 19-year mean tide cycle presented in Table G-1, the higher high tide (5.7 feet MLLW at Golden Gate) was exceeded 49 times out of 59 concurrent years of record, for a reliability of 17 percent. Similar statistics for low tides show a 20 percent reliability assuming MLLW.

To model an appropriate San Francisco Bay tidal cycle during a one-percent runoff event, the Corps of Engineers' 19-year mean tide cycle for the Golden Gate Station is adjusted as discussed herein and translated to the Palo Alto Yacht Harbor. Elevations for each critical point in the tide cycle are adjusted based on the one-percent conditional probability of coincident occurrence with the annual maximum discharge at San Francisquito Creek as described by Dixon (1986), whose hypothesis was that high tide events tend to occur the same day as flood flow events using conditional probability:

$$P(x,y) = P(x|y)\,P(y)$$

where $P(x,y)$ is the probability of occurrence of x and y; $P(x|y)$ is the probability of occurrence of x given y; $P(y)$ is the probability of occurrence of y; x is tide elevation; and y is maximum annual peak discharge. Since we are interested only in annual maximum discharges, $P(y)$ is one and the probability of joint occurrence, $P(x,y)$, is equal to the probability of x given y.

Tide cycle points (HH, H, L, and LL) are taken from fitted probability curves using the median plotting position for every recorded tide extreme that occurred within 24 hours of the recorded maximum annual discharge; and shown in the "risk-based design column" on Table G-4. (The risk of annual exceedance is one percent compared to 50 percent for the 19-year mean elevations.) Figure G-7 shows the complete design tide cycle plotted with the actual tides for the February 2-3, 1998 storm event, and the 19-year mean tide cycle. (Plotted tide cycles are at the Palo Alto Yacht Harbor, adjusted to the NGVD 1929 datum.)

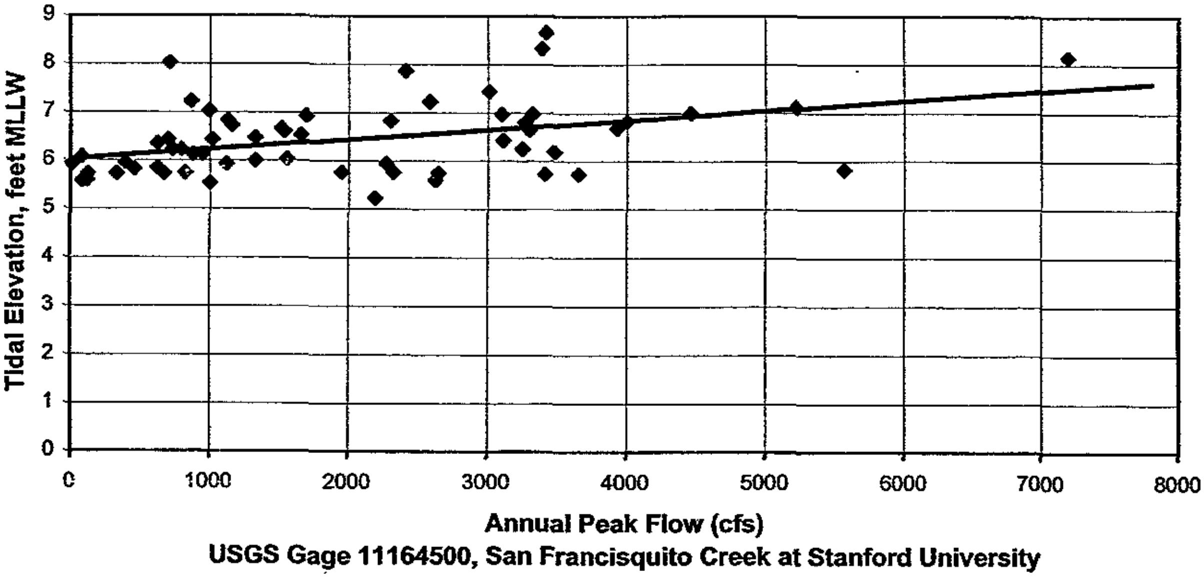


Figure G-5. Tide Elevations, Higher High Water
NOAA Golden Gate Station

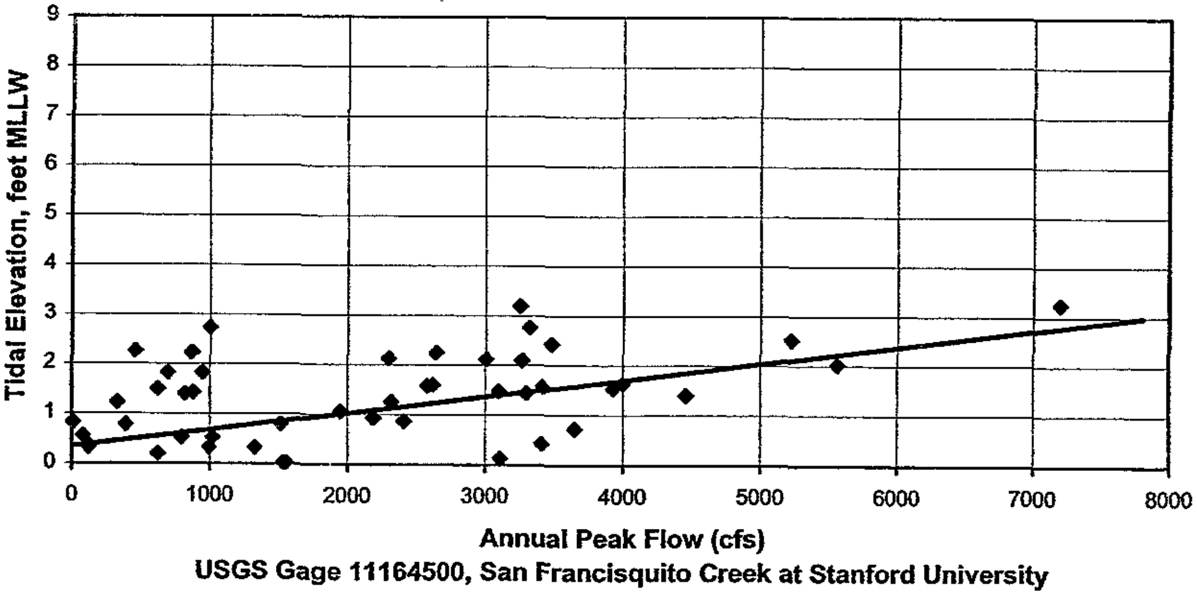


Figure G-6. Tide Elevations, Lower Low Water
NOAA Golden Gate Station

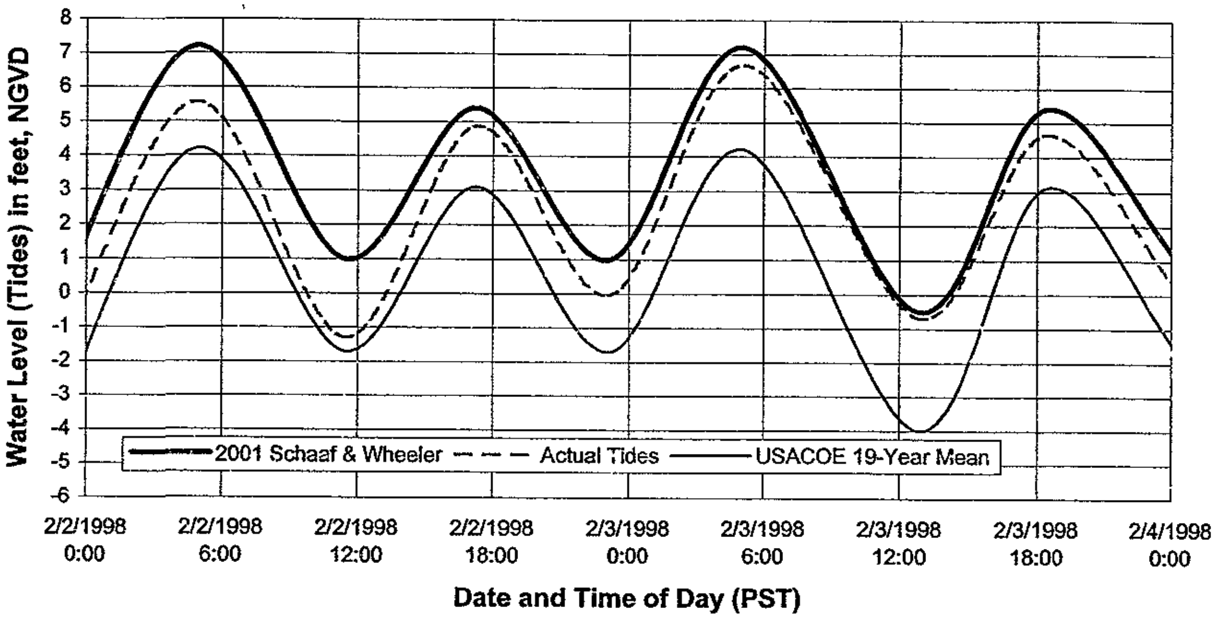


Figure G-7. Comparison of Tide Cycles at Palo Alto Yacht Harbor

Table G-4
Comparison of Risk-Based Design Tide Cycle with 19-year Mean Design Tide Cycle

(All elevations feet NGVD)

Tide	19-Year Mean	Risk-Based Design	Increase
Higher High	4.2	7.2	3.0
High	3.1	5.4	2.3
Low	-1.7	1.0	2.7
Lower Low	-4.0	-0.5	3.5

Storage Capacity of the Palo Alto Flood Basin

Stormwater runoff transports sediment and debris downstream via the creek channels. Some of this debris and sediment are ultimately deposited in the Palo Alto Flood Basin, and over time, the basin's storage capacity could be diminished. During large storm events, reduced capacity could raise water levels and impact water surface elevations in the creeks. As part of this study, the current storage capacity of the PAFB has been determined. Towill and MacKay & Somps conducted an aerial topographic survey of the PAFB in April 1999. From this topographic survey, a new elevation-storage curve was developed. This curve was plotted against the elevation-storage curve that had been prepared by SCVWD in their 1974 PAFB analysis. Both curves are shown in Figure G-8, which indicates that there has been minimal change in storage capacity over the past 25 years.

Computer Simulation of Palo Alto Flood Basin Operation

In the current study, the operation of the Palo Alto Flood Basin is modeled using HEC-UNET, a one-dimensional unsteady flow model for open channels. The model simulates the operation of the PAFB over seven days, with basin stage computed every 15 minutes. Stored water in the basin is discharged to San Francisco Bay though Mayfield Slough, which begins at the downstream face of the tide gates. Mayfield Slough channel geometry has been modeled using map information from the District's 1971 Baylands Flood Control Planning Study and the NOAA nautical chart for the southern part of San Francisco Bay. To examine PAFB operation during an extreme event, local runoff hydrographs in Adobe Creek, Barron Creek, Matadero Creek, and the Coast Casey Pump Station from the design one-percent, 72-hour storm discussed in Appendix F are entered as upstream boundary conditions for the flood basin. Stored water overtops the basin at an approximate elevation of 6 feet NGVD based on existing levee elevations.

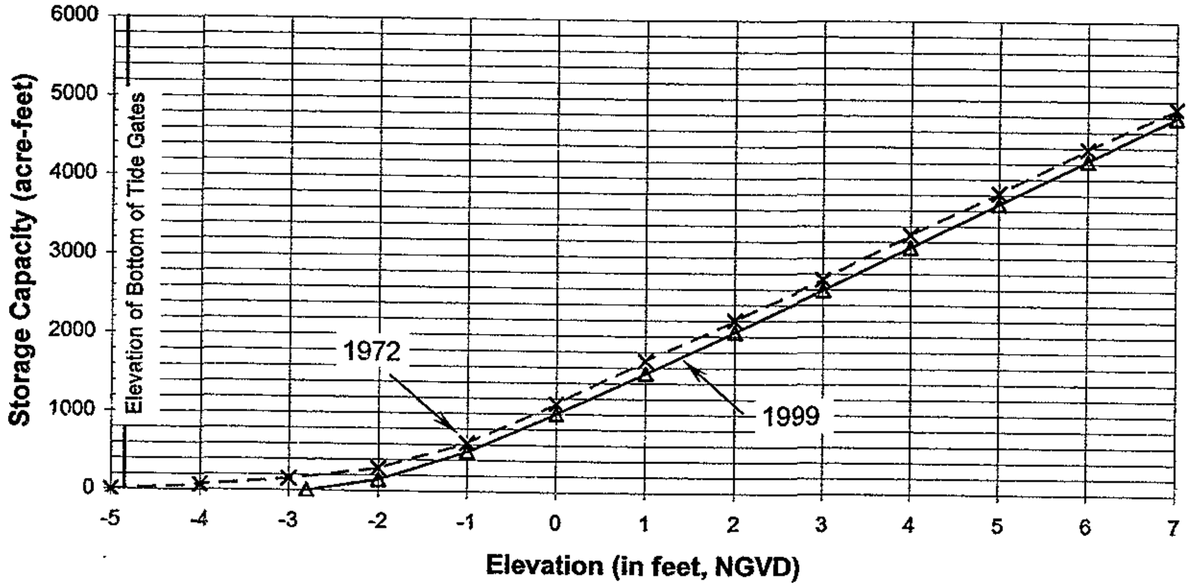


Figure G-8. Palo Alto Flood Basin Elevation-Storage Curve

The design tide cycle is input as a downstream stage boundary condition. Since evidence suggests that the storm surge can last for several days, if not weeks, the cycle repeats itself throughout the simulation. Initial conditions in the flood basin assume that the water level inside the basin is equal to the lower low tide elevation of the design tide cycle. As discussed previously, storm surged tides can be experienced for several days before and after periods of extreme rainfall and runoff. Higher than expected low tides will not allow the basin to empty itself below the lowest tide elevation, and it is assumed that antecedent runoff would fill the basin to the low tide level.

According to the 1974 District analysis of PAFB operation, "...the most severe condition for storing the maximum volume of flood water would have to be determined from several combinations of the time of occurrence of the peak flow and the tidal cycle. This critical condition would then be considered as the final design criterion." (SCVWD, 1974) Consequently, a sensitivity analysis has been performed to determine how tide elevations and timing affect stage in the PAFB.

Particular attention has been focused on the PAFB stage at critical points of the inflow and stage hydrographs. To do this, the tide cycle is shifted in time by 15 minutes to examine worst-case stage in the PAFB at desired ordinates on the inflow hydrographs. The timing of the tides does affect stage in the PAFB. The maximum peak stage in the PAFB is observed to occur when the 72-hour storm begins during ebb tide, approximately two hours before the lower low tide.

Figure G-9 presents the results of model simulations for existing conditions in the PAFB based on 72-hour, one-percent design storm inflows and the storm-adjusted design tide as developed from the tide cycle analysis. It can be seen that the inflows from Matadero Creek and the combined inflows from Barron/Adobe Creeks enter the flood basin nearly simultaneously. With the tides in San Francisco Bay peaking as the inflows enter the basin, the tide gates cannot discharge from the basin until the tide recedes, thus resulting in a substantial rise in PAFB stage. The peak stage that would be observed during such an event is predicted to be 6.5 feet NGVD, which would be limited in the field to 6 feet NGVD by levee overtopping.

Additional sensitivity analyses have been performed to define the greatest flood basin stage coincident with peak Matadero Creek inflow, which occurs 42 hours into the design storm. Analysis shows that the highest PAFB stage 42 hours into the storm is 4.6 feet (NGVD) when the storm begins approximately four hours after the lower low tide. Table G-5 summarizes these results.

Table G-5
Maximum PAFB Stage and PAFB Stage at Peak Matadero Creek Inflow for Risk-Based Design

Time	Matadero Flow (cfs)	PAFB Stage (ft. NGVD)
42 hours	3,100	4.6
47 hours	1,250	6.5

PAFB Elevations for FEMA Mapping

FEMA's *Guidelines and Specifications for Study Contractors* (FEMA 37) does not provide an explicit criterion for the analysis of tidal flooding coincident with riverine flooding. Guidelines for coastal flood study documentation state only that "adjustments to account for the combined probability of coastal and riverine flooding shall be fully described and reported..." Traditionally, when the use of slope-area (normal depth) computations are not appropriate in tidally influenced areas, FEMA has adopted the mean higher high tide level (MHHW) as the starting water surface elevation. The Corps of Engineers also uses this approach. (Dixon, 1986)

The use of MHHW as a starting water surface is an actuarial approach to joint probability, rather than a risk-based design approach as presented earlier. In effect there is a 50 percent chance that the actual higher high tide is greater than assumed, since MHHW is the average of all astronomic highest tides within the 19-year epoch. To reflect the storm-surge phenomenon described in this chapter, a modification is made to the use of MHHW as the starting water surface in San Francisco Bay. In lieu of the average astronomic tide cycle, the average coincident runoff tide cycle is used. (Tide points are obtained from the aforementioned conditional probability plots at the 50 percent exceedance level.) The average highest tide from this cycle is 4.7 feet NGVD at the Palo Alto Yacht Harbor, as opposed to a MHHW elevation of 4.2 feet NGVD. The remaining average coincident tide cycle is summarized in Table G-7.

When the Palo Alto Flood Basin Analysis is repeated with the average coincident tide cycle, the peak basin stage is less than the higher high tide of 4.7 feet. FEMA guidelines suggest that the worst-case levee failure scenario should be mapped. It the outboard levees do not hold, as must be assumed in the FEMA analysis, the flood basin is exposed to direct tidal action from San Francisco Bay, so its maximum water surface would be equivalent to the highest average coincident tide. A starting water surface of 4.7 feet in the PAFB will govern the FEMA water surface profile analysis, assuming that

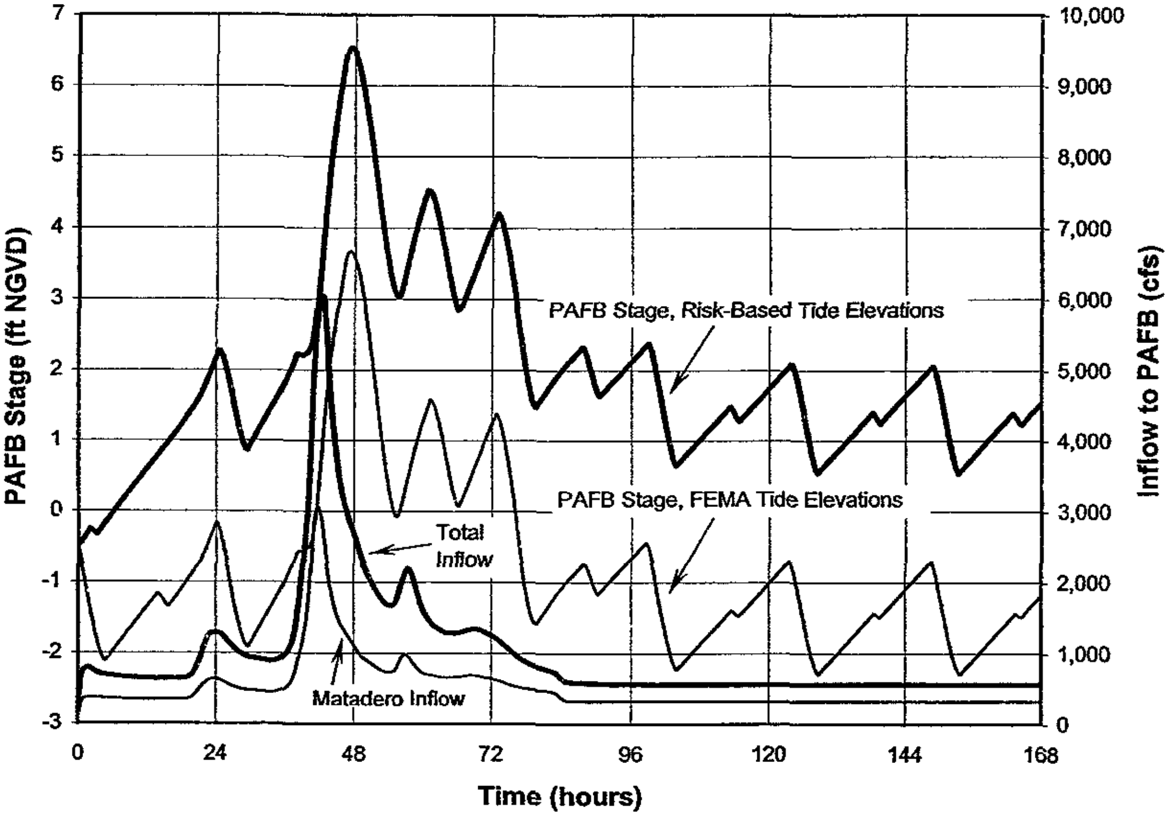


Figure G-9. Inflow to and Stage in Palo Alto Flood Basin 72-Hour Design Storm

the Renzel Marsh levees hold as a worst-case condition. Because the timing of a levee failure scenario is so difficult to predict, maximum assumed flood basin stage will not be time-variant in the FEMA analysis.

Table G-7
Comparison of Average Coincident Tide Cycle with 19-year Mean Tide Cycle for FEMA Mapping
(All elevations feet NGVD)

Tide	Average Coincident	19-Year Mean	Increase
Higher High	4.7	4.2	0.5
High	3.3	3.1	0.2
Low	-1.0	-1.7	0.7
Lower Low	-3.0	-4.0	1.0

Flood Basin Operation in 1998

During the February 1998 runoff event, the District recorded a high water mark of 7.5 feet NGVD at West Bayshore Road. Based on the USGS's final discharge estimate for this event, and subsequent hydrologic analyses, the estimated peak discharge from Matadero Creek to the Flood Basin in February 1998 is about 3,000 cfs. These measurements have been used to calibrate channel roughness values in this reach.

This reach of Matadero Creek essentially conveys flows like a conduit, with the vast majority of conveyance between the vegetated banks and little conveyance within the overbanks. By placing HEC-2 bank stations at the demarcation between clear channel and vegetation, and using an "n" value of 0.025 within the low flow maintenance channel and 0.150 for the vegetated overbanks, it is possible to match the high water marks recorded during the February 1998 event for the estimated discharge.

Channel losses through the constricted reach appear to have controlled the hydraulic grade at Highway 101 rather than the stage in the flood basin, based on estimated conditions in 1998 (water surfaces are given at the *upstream* face of *West* Bayshore Road, the southwesterly frontage road):

For 3,000 cfs with PAFB at 3.5 WSEL at Bayshore = 7.5 (match)

For 1,200 cfs with PAFB at 5.7 WSEL at Bayshore = 6.0

For existing channel conditions, the same phenomenon is observed during the peak of the design hydrograph, indicating that the maximum base flood water surface elevation at the *downstream* side of *East* Bayshore Road is controlled by channel losses through this reach rather than the stage in the flood basin. Water surface elevations shown in Table G-8 are based on the UNET model of PAFB operation, using the San Francisco Bay tide cycle that produces the highest PAFB stage at the time of peak Matadero Creek inflow. Base flood discharges and elevations for the six hours surrounding Matadero Creek's peak discharge are provided for existing conditions under the emergency operating plan (partial 300 cfs diversion), and for design flow conditions (full 600 cfs diversion).

Table G-8
Controlling WSEL at Bayshore Freeway
(Stage in Feet NGVD)

		Partial Diversion		*Full Diversion*	
Time (hr)	*PAFB Stage*	$Q_{1\%}$ *(cfs)*	*WSEL at 101*	$Q_{1\%}$ *(cfs)*	*WSEL at 101*
40	3.32	1,500	4.73	1,800	5.25
41	3.97	2,560	6.23	2,860	6.90
42	4.58	2,800	6.49	3,100	7.19
43	5.31	2,200	6.33	2,500	6.77
44	5.44	1,640	6.07	1,940	6.34
45	5.34	1,300	5.78	1,600	6.00

After 42 hours of rainfall during the design 72-hour storm, Matadero reaches its peak discharge downstream of Highway 101. Roughness coefficients for the lowest reach of channel, calibrated to replicate high water marks from February 1998, result in the given water surface elevation at the downstream face of the footbridge on the north side of East Bayshore Road. As the PAFB stage continues to rise until it reaches a peak two hours later, energy loss through the channel is controlling the hydraulic grade at Highway 101 with both partial and full Barron Creek diversions.

DETAILED INFORMATION IN CLOMR APPLICATION

Readers interested in finding out more about the detailed Palo Alto Flood Basin Operation analysis are encouraged to consult the CLOMR Application on file at the District. Within this separately bound document, the following data are available:

- Coincident tide frequency analyses.
- Conditional probability plots for each point on the tide cycle.
- Spreadsheets with results of UNET analysis for PAFB stage hydrographs with these downstream boundary conditions:

    1) Design tide cycle for maximum stage at 42 hours

    2) Design tide cycle for maximum PAFB stage

    3) FEMA tide cycle for maximum PAFB stage

APPENDIX H
HYDRAULIC ANALYSIS METHODOLOGIES

Base flood elevations within Matadero and Barron Creeks are estimated using a one-dimensional steady state flow backwater analysis. One-percent water surface elevations are established using the U.S. Army Corps of Engineers HEC-2 backwater analysis program. Supercritical flow analyses are also performed using HEC-2 forewater capabilities.

Channel geometry information has been supplied by the Santa Clara Valley Water District. This topographic data includes record drawings for flood conveyance facilities completed in 1997, additional cross-sectional information for Matadero Creek below El Camino Real (August 1997 survey), cross-sections for Matadero Creek upstream of El Camino, and cross-sections for Barron Creek between Adobe Creek near Highway 101 and Foothill Expressway. This information is supplemented by field surveys performed by Schaaf & Wheeler at every bridge or culvert crossing on both creeks between Highway 101 and Foothill Expressway. The reach of Matadero Creek between the Palo Alto Flood Basin and Highway 101 was surveyed in detail for this planning study.

Flow Regimes

Flood flows can be carried within channels either as "subcritical" flow or "supercritical" flow, often referred to as "tranquil" and "rapid" flow, respectively. It is not the velocity of flow, however, that distinguishes the flow regime; rather, the flow regime is defined by how fast the water is moving relative to the velocity of the wave that results from a small disturbance in the water surface. Disturbances in subcritical flow move upstream; disturbances in supercritical flow cannot move upstream because such waves must be swept downstream. The Froude number (F_r), which is analogous to the Mach number for gas flow, is defined as the ratio of stream velocity to wave velocity:

$$F_r = \frac{v}{\sqrt{g\,y}}$$

where v is the stream velocity, g is the acceleration of gravity, and y is water depth. Froude numbers greater than unity signify supercritical flow (stream velocity greater than wave velocity), and Froude numbers less than one indicate subcritical flow. When the Froude number is close to one, however, flow becomes rather unstable, characterized by standing waves and other disturbances that may tend to propagate upstream or downstream depending upon the state of flow at any instant. Such flow is termed "critical". Matadero Creek's natural slope is such that base flood conditions are characterized by flow regimes that are close to critical. Channel controls can therefore have a significant effect on how extreme discharges are carried in Matadero Creek.

Channel Controls

The preceding flow regime discussion is important to an understanding of channel hydraulics along the lower reaches of Matadero Creek. In subcritical flow, a disturbance caused by a channel feature can influence flow further upstream, even to the point of making previously supercritical flow subcritical. Conversely, supercritical flow cannot be influenced by downstream channel features.

Whether flow is subcritical or supercritical depends on several factors including channel shape, channel slope, channel roughness, and discharge. For the design one-percent discharge in Matadero Creek and uniform flow within long stretches of the concrete channel, flow should remain supercritical over the range of channel roughness values used in design. As illustrated in Figure 5-1, however, channel features such as downstream backwater or a bridge can act as a channel control, and change the flow regime upstream of that feature.

This hydraulic principle results in the primary discrepancy between Matadero Creek channel design and actual performance downstream of Alma Street. What was thought to be supercritical flow is indeed subcritical because of several bridge constrictions. Subcritical flow will be slower and deeper than supercritical flow of the same discharge, which can mean less-than-anticipated freeboard.

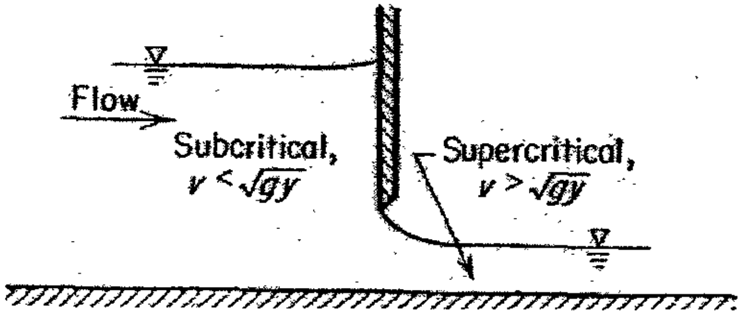


Figure H-1. Bridges as a Generator of Subcritical Flow (Henderson, 1966)

Channel Roughness

Flow resistance in an open channel is essentially the same as resistance to flow within a closed pipe running full. Retarding forces created by the shear force at the boundary are overcome by a force acting in the direction of flow. For closed pipe flow, this force is supplied by a pressure gradient; in open channel flow, the weight of the water flowing down a slope provides the propulsive force. In one-dimensional analysis performed using HEC-2, a single parameter known as “Manning’s n” factor is used to represent the retarding forces.

Manning's equation for flow resistance is based on empirical work dating to the nineteenth century, but has proven to be reliable in practice and popular within the engineering community. Values for "n" are widely published in the literature, and in the absence of high water marks with which to calibrate stream reaches, are often relied upon for channel design. When selecting roughness values for design, it is important to remember that in one-dimensional flow, Manning's "n" accounts for the flow resistance due to a host of hydraulic phenomena beyond boundary shear. These factors may include the effects of eddies, cross-waves, superelevation, bed forms, sediment and debris.

Several sources have been used to estimate roughness factors for water surface profile determination within Matadero and Barron Creeks. These include "n" values published by Henderson (1966) and Chow (1959), field observation with engineering judgement, and procedures outlined by the Corps of Engineers for roughness values within concrete lined channels (ASCE, 1995). Table H-1 summarizes design channel roughness values used in this planning study. Given the uncertainty in "n" value selection, a range of "n" values is used to examine channel performance. Lower values tend to increase channel velocity which may be important in terms of scour or wave formation. Higher values tend to maximize water depth, and will generally set freeboard requirements.

Table H-1
Manning's "n" Values Used for Channel Design

Description	*High "n" for depth*	*Low "n" for velocity*
Concrete Lined	0.015	0.011
Concrete Lined, Gravel Bottom	0.020	0.011
Excavated Earth	0.035	0.025
Revegetated Channel	0.040	0.025
Natural Stream	0.060	0.045

Bridge Hydraulics

In addition to the energy required to overcome channel resistance, structures such as bridges and culverts also cause energy losses, which can result in a higher water surface profile. Energy losses take place in the reaches just upstream and downstream from each structure as flow contracts and expands into and out of the bridge or culvert. The following contraction and expansion coefficients for channel transitions are used in the hydraulic models (Table H-2). Wherever turbulent conditions create the potential for energy loss, such as the outfall of Palo Alto's storm water pump station, contraction and expansion coefficients are increased. Other transitions include channel bends, and maintenance access ramps.

Table H-2
Expansion and Contraction Coefficients

Transition Type	*Contraction*	*Expansion*	*Source*
Gradual	0.1	0.3	HEC
Warped	0.1	0.2	Chow
Wedge	0.3	0.5	Chow
Square End	0.3	0.75	Chow

To compute energy losses resulting from flow through the bridge or culvert itself, two approaches are available through HEC-2. The "normal bridge" method handles a bridge section in the same manner as a natural river section, except that the area between the low chord of the bridge (soffit) and the top of road is subtracted from the total cross-sectional area, and the wetted perimeter is increased where water is in contact with the bridge. Increased frictional resistance due to the added wetted perimeter is included in the energy loss through the structure.

The "special bridge" method, which is used in this planning study, computes losses through the structure for either low flow, pressure flow, weir flow over the top, or a combination of these. Changes to the water surface profile resulting from the bridge are calculated based on hydraulic formulae that estimate the change in energy and water surface elevation through the bridge. The "special culvert" routine is also available to perform the same function for standard culvert shapes.

Many of the problems associated with the 1988 planning study's hydraulic analysis stem from the unintended use of the normal bridge routine in lieu of the special bridge method. Pressure flow computations must be performed with the use of the special bridge routine, and underestimation of energy loss through pressurized bridges at Greer Road, Louis Road, and Ross Road led in part to the establishment of inadequate freeboard for these reaches. When bridges become pressurized, they behave as orifices to flow, whose discharge is governed by the following fundamental equation:

$$Q = C A \sqrt{2 g \Delta h}$$

where Q is discharge; C is a coefficient of discharge; A is the cross-sectional area of the bridge opening; g is the acceleration of gravity; and Δh is the difference in energy head across the bridge.

For a square-edged orifice, or "orifice in thin plate", flow is contracted as it passes through the opening and a discharge coefficient of 0.6 is typically assumed. When the orifice becomes submerged and is in the form of the "short tube" characteristic of a roadway crossing, the coefficient of discharge increases to about 0.8 for a length-of-tube to diameter ratio of four (Schoder, 1927). Bridge openings along Matadero Creek are either rectangular or trapezoidal in shape with three sides of the orifice formed by the channel floor and side slopes. This has the effect of suppressing the orifice contraction on three sides. Experimental data also suggest an increase of about 0.04 in the coefficient of discharge for each side on which the orifice is flush with a wall (Schoder, 1927). Therefore a total of 0.12 is added to the short-tube coefficient of 0.8 to produce a net 0.92 discharge coefficient.

HEC-2 does not directly use the orifice discharge coefficient, but rather a loss coefficient, XKOR, which is related to the discharge coefficient by:

$$XKOR = \frac{1}{C^2}$$

For C equal to 0.92, the corresponding XKOR is 1.18; a minimum XKOR of 1.2 is used. Rounding the upstream edge of an orifice further decreases the contraction and increases the discharge. Procedures are available to compute discharge coefficients based on edge rounding, bridge opening size, and friction losses through the bridge itself. However, since only the bridge soffit is rounded, any increase in discharge due to this rounding is neglected in hydraulic analysis, and the XKOR value never falls below the minimum 1.2 for orifice flow discussed above.

Superelevation

Just upstream of the Southern Pacific Railroad, the improved rectangular Matadero Creek channel makes two ninety-degree curved bends in a relatively short distance. The centrifugal force caused by flow around a curve raises the water surface on the outside wall of the curve, and depresses the water surface along the inside wall. This phenomenon is referred to as superelevation. In addition, curved channels tend to create secondary helicoidal flows that may persist downstream of the curve. The maximum amount of superelevation above the level water surface predicted by HEC-2 is given by the following equation (ASCE, 1995):

$$\Delta y = C \frac{V^2 W}{g r}$$

where Δy is the rise in water surface; C is a coefficient (0.5 for subcritical flow in a simple circular curve in a rectangular channel; 1.0 for supercritical flow in the same type of curve); V is the mean channel velocity; W is the channel width; g is the acceleration of gravity; and r is the radius of channel centerline curvature. Superelevation is checked with both high and low Manning's "n" values to determine the most critical case for wall freeboard.

APPENDIX I
FLOODWALL ELEVATION MITIGATION

Floodwall construction would result in significant visual changes along much of the project reach between Highway 101 and Alma Street. Throughout this reach, increases in floodwall heights of up to more than three feet are needed in order to meet FEMA and District freeboard requirements. Most of the impacted project reach is residential, and properties abut directly against the creek right-of-way in many places. For some residences, the floodwalls serve as defacto backyard fences. Higher floodwalls would be more visually obstructive than they are now, particularly at bridge headwalls where residents currently enjoy views of the foothills to the southwest, and from some locations, views of the baylands to the northeast.

Matadero Creek, while not a natural stream between Bayshore and El Camino, "...could be considered an important scenic and aesthetic resource in this urban environment because it does contain trees and other riparian vegetation. The development of proposed floodwalls would block existing views of the creek channel from the roadway bridge crossings of Greer Road and Louis Road and would change the visual character of these roadways." (Powers & Associates, 2001) Table I-1 lists existing bridge headwall height as measured from the sidewalk at various roadway crossings, comparing them to the heights required to meet FEMA and District freeboard standards.

Table I-1
Bridge Headwall Heights for FEMA Freeboard

Bridge Location	*Existing Headwall (feet)*	*To Meet Freeboard (feet)*
West Bayshore Road	2.5	2.5
Greer Road	3.8	6.6
Louis Road	2.8	4.8
Ross Road	2.3	3.1
Middlefield Road	2.3	2.3
Cowper Street	2.4	2.4
Waverley Street	2.2	3.7
Bryant Street	0.0	0.0
Alma Street / SPRR	0.6	0.6

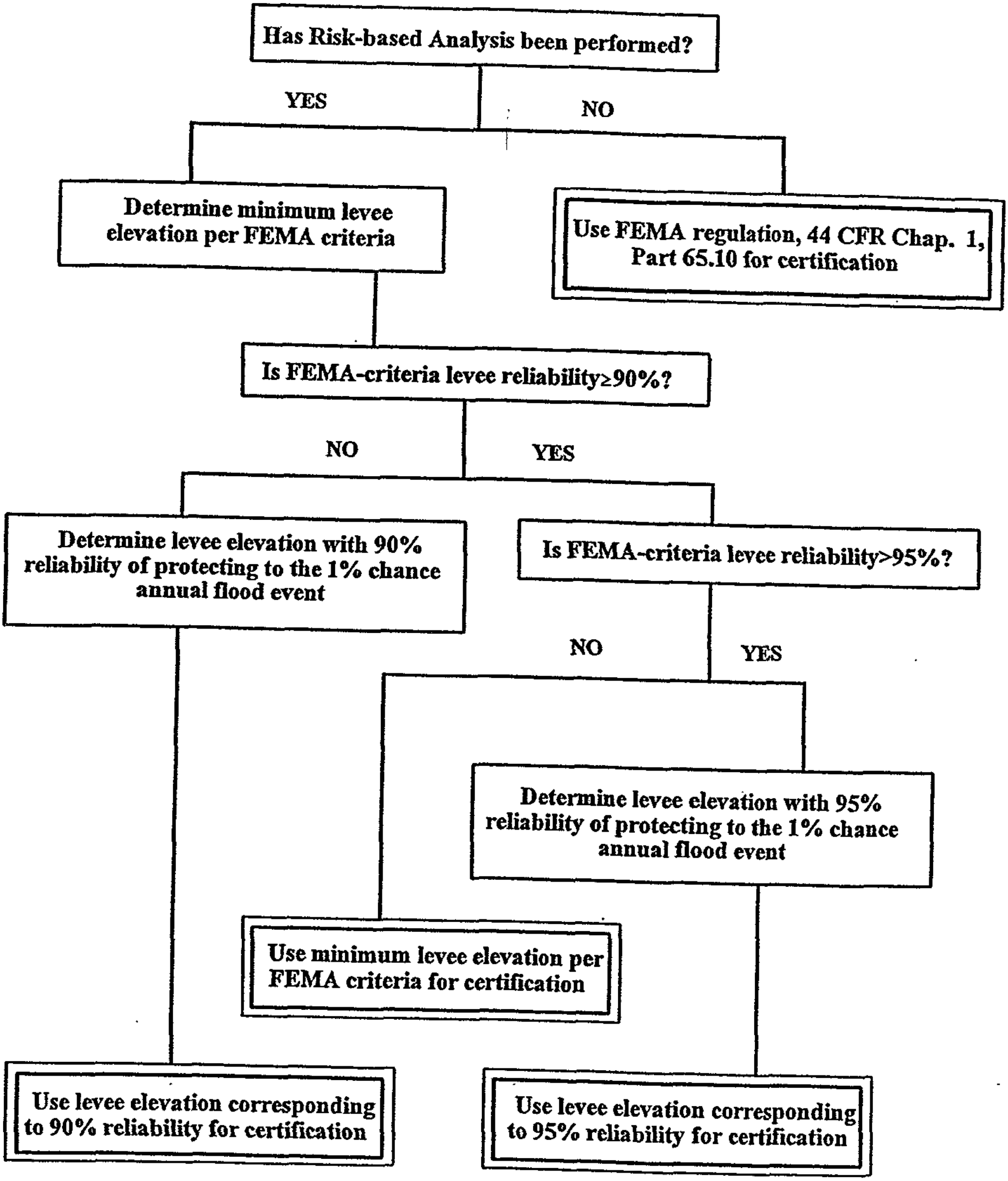
Public outreach efforts indicate that floodwall height is one of the most sensitive issues with the Palo Alto community. The loss of views along the creek corridor associated with headwalls greater than seven feet above the sidewalk is a serious impact caused by proposed channel remediation. To partially mitigate this impact, a procedure used by the U.S. Army Corps of Engineers to reduce required freeboard is employed. This risk-based procedure, which is described below, has been developed by the US. Army Corps of Engineers and FEMA for federal projects. Regulations published in NFIP 65, 10(b)(1)(ii), indicate that FEMA will consider freeboard reductions of up to two feet based partly on such statistical analysis, and FEMA approved the risk-based procedure for Matadero Creek on June 18, 2002.

The attached Corps of Engineers "Levee Certification Decision Tree" (USACE, undated) is applied to Matadero Creek floodwall elevations between West Bayshore Road (Section 9568) to the downstream face of the Alma Street culvert (Section 17544). Upstream from Alma Street / SPRR, base flood discharges are contained below natural ground, so freeboard is not required.

The Corps defines "reliability" as the percent chance of non-exceedance given the occurrence of the design one-percent event. For example, a levee with 90 percent reliability would be one that has a 90 percent chance of containing the one-percent discharge.

After performing statistical analyses for reliability similar to the estimation of confidence limits, minimum levee elevations are determined using FEMA criteria. If the FEMA criteria result in a levee whose reliability is less than 90 percent, the levee is set at that elevation with a 90 percent reliability of protecting against the one-percent discharge. If the FEMA-criteria levee reliability exceeds 90 percent, then the FEMA-criteria levee reliability is compared against the 95 percent reliability. If the FEMA-criteria levee reliability is less than the 95 percent reliability, then the minimum levee elevation is set per FEMA criteria. If FEMA criteria result in a levee whose reliability exceeds 95 percent, then levee certification is based on 95 percent reliability.

LEVEE CERTIFICATION DECISION TREE


Has Risk-based Analysis been performed?
YES
NO
Determine minimum levee elevation per FEMA criteria
Use FEMA regulation, 44 CFR Chap. 1, Part 65.10 for certification
Is FEMA-criteria levee reliability≥90%?
NO
YES
Determine levee elevation with 90% reliability of protecting to the 1% chance annual flood event
Is FEMA-criteria levee reliability>95%?
NO
YES
Determine levee elevation with 95% reliability of protecting to the 1% chance annual flood event
Use minimum levee elevation per FEMA criteria for certification
Use levee elevation corresponding to 90% reliability for certification
Use levee elevation corresponding to 95% reliability for certification

FEMA Criteria = 1% chance median annual flood event plus three feet of freeboard
RELIABILITY = % chance non-exceedance given the 1% chance annual event occurs

Two major factors influence the reliability of any flood protection system: the base discharge estimate, and estimates of channel roughness. Risk-based analysis establishes confidence limits for each factor. To predict the reliability of the estimate base flood profile, 2000 random profiles have been generated using HEC-2 for various combinations of discharge and Manning's "n". Using the general form of the confidence limit equation from Bulletin 17B, Appendix 9 (USGS, 1982):

$$\mathit{Probability}\ [L_{p,c}(X) \leq X_p^* \leq U_{p,c}(X)] = 2c - 1$$

where X_p^* is the "true" or population logarithmic discharge with exceedance probability p. Upper and lower confidence limits for X_p^* with confidence level c are defined by $U_{p,c}(X)$ and $L_{p,c}(X)$, respectively; based on observed flood records, X, such that the upper confidence limit lies above X_p^* with probability c and the lower confidence limit lies below X_p^* with probability c. The general form of the confidence limits is given by:

$$U_{p,c}(X) = \overline{X} + S\left(K_{p,c}^{U}\right)$$

$$L_{p,c}(X) = \overline{X} + S\left(K_{p,c}^{L}\right)$$

in which X and S are the logarithmic mean and standard deviation for the estimated frequency curve (Appendix F), and $K_{p,c}^{U}$ and $K_{p,c}^{L}$ are upper and lower confidence coefficients, which approximate the non-central t-distribution using the following approximate formula:

$$K_{p,c} = \frac{K_{G_w,p} \pm \sqrt{K_{G_w,p}^2 - a\ b}}{a}$$

where $K_{p,c}$ are the upper and lower confidence limits depending upon the sign of the square root, G_w is the weighted skew coefficient, and a and b are coefficients related to the standard normal deviate, z_c by:

$$a = 1 - \frac{z_c^2}{2\ (N - 1)}$$

$$b = K_{G_w,p}^2 - \frac{z_c^2}{N}$$

and N is the systematic record length (45 years for Matadero Creek). Based on a frequency analysis of streamflow records for the USGS gaging station at Matadero Creek, the following equations are used to generate 2000 random flowrates fitting the frequency curve:

Letting c be a random number between 0 and 1,

$K_{Gw,.01} = K_{-0.33,.01} = 2.0825$ and N = 45, and

z_c = standard normal deviate = f(p = random c).

$$K_{.01,c} = \frac{2.0825 + \frac{z_c}{|z_c|}\sqrt{4.3368 - a\ b}}{a}$$

Using these formulae, 2000 randomly generated flowrates fitted to the Matadero Creek frequency distribution are generated. The discharge values generated range from 1,210 cfs to 5,380 cfs with a mean value of 2,100 cfs. (Weighted skew is adjusted so that the average generated value is consistent with the one-percent weighted design discharge.) To simplify the risk-based analysis, local storm drain capacity at Alma is assumed to be a constant 100 cfs, and the pump station discharge near Highway 101 is assumed to be a constant 300 cfs, and the diversion from Barron Creek is assumed to be a constant 600 cfs.

A similar procedure is used to randomly generate a range of Manning's "n" values for Matadero Creek between Highway 101 and Alma Street. The Corps of Engineers has derived a formula to account for variation of the standard deviation with magnitude of Manning's roughness coefficient for a log-normal probability density function (HEC, 1986):

$$SD = n\sqrt{e^{(.582\ +\ .10\ \ln\ (n))^2} - 1}$$

Using the range of Manning's roughness coefficients given in Table I-2, another 2000 random numbers between 0 and 1 are used to generate a distribution of "n" values, which together with the 2000 random estimates of discharge, form the basis of a hydraulic analysis of floodwall reliability. Downstream of Highway 101, a conservative approach to simplify risk analysis for the overflow bypass and natural channel bifurcation has been taken as described in subsequent paragraphs.

Table I-2
Random Generation of Manning's "n"

Channel Reach	*Range of "n"*	*Mean "n"*	*Standard Deviation*
Under Hwy 101	.015 - .020	0.018	0.003
Hwy 101 to Greer Rd	.025 - .035	0.030	0.007
Greer Rd to Alma St	.013 - .016	0.015	0.002

Since this procedure is for risk-based design, the Palo Alto Flood Basin's starting water surface elevation is not equal to 4.7 feet NGVD as in the case of the FEMA mapping analyses presented in Appendix G. A true risk-based design would need to factor uncertainty in estimates of Adobe and Barron Creek discharges, tide estimates, and structural levee reliability. Since the data necessary to evaluate any of these factors are not available, however, the following worst-case approach is used to establish a starting backwater at Highway 101 for risk analysis:

1) One-percent coincident tide elevations are assumed in San Francisco Bay.

2) Peak Matadero Creek discharge coincides with the highest PAFB stage.

3) High Manning's "n" values are assumed in the channel and in the overflow bypass.

4) The maximum randomly estimated one-percent discharge of 5,380 cfs at the Matadero Creek gage is used.

5) The water surface elevation at East Bayshore Road is established as the higher of case (a), where outboard levees hold and the Renzel Marsh levee is overtopped without failing; or case (b), where all outboard levees fail. The worst case is (b) with WSEL = 7.2 feet NGVD.

Two thousand hydraulic runs with random combinations of channel roughness and discharge have been made to determine 90-percent and 95-percent floodwall reliability at each bridge crossing. Table I-3 presents the results of the risk-based analysis using the Corps' levee certification decision tree. Table I-4 provides a comparison of proposed floodwall heights, FEMA freeboard standards, and floodwall reliability. Proposed floodwall elevations are established so that under no circumstances is freeboard less than two feet.

The risk-based approach is used only for the reach of Matadero Creek subject to continued mapped inundation from coastal flooding. That is, for the reach between West Bayshore Road and Ross Road. Upstream of Ross Road, FEMA freeboard criteria are used for remedial design.

Summary results for the random generation of water surface elevations at each bridge location are provided in the CLOMR Application, which is bound separately and on file at the District.

Table I-3
Matadero Creek
Corps Levee Certification Decision Tree

Location	EXISTING			Design WSEL	FEMA CRITERIA[2]		90% Reliability	*FEMA >90% Reliability?*	95% Reliability	*FEMA >95% Reliability?*	PROPOSED			Actual Reliability
	Adjacent Grade[1]	Top of Wall[1]	Wall Height		Top of Wall	Wall Height					Top of Wall	*Wall Height* above Adjacent Grade	Freeboard	
	(NGVD)	(NGVD)	(feet)	(NGVD)	(NGVD)	(feet)	(feet)		(NGVD)		(NGVD)	(feet)	(feet)	%
W. Bayshore	6.0	9.0	3.0	5.71	not reqd	3.0	8.2	No	8.4	No	10.0	4.0	4.3	99.9
D/S Greer	6.5	9.0	2.5	7.90	11.9	5.4	9.3	Yes	9.6	Yes	10.0	3.5	2.1	98.7
U/S Greer	6.5	10.0	3.5	8.81	12.81	6.3	10.7	Yes	11.2	Yes	11.2	4.7	2.4	95
D/S Louis	8.0	10.6	2.6	9.26	13.26	5.3	10.9	Yes	11.5	Yes	11.5	3.5	2.2	95
U/S Louis	8.0	11.2	3.2	10.22	14.22	6.2	12.8	Yes	13.7	Yes	13.7	5.7	3.5	95
D/S Ross	10.0	13.2	3.2	11.21	15.21	5.2	13.0	Yes	13.8	Yes	13.8	3.8	2.6	95
U/S Ross	11.0	13.2	2.2	12.32	16.32	5.3	16.0	Yes	17.7	No	16.3	5.3	4.0	92
D/S Middlefield	15.0	16.8	1.8	14.14	not reqd	1.8	16.3	No	17.5	No	17.5	2.5	3.4	95
U/S Middlefield	15.5	17.2	1.7	14.64	not reqd	1.7	18.5	No	21.0	No	18.5	3.0	3.9	90
D/S Cowper	18.3	19.0	0.7	16.94	not reqd	0.7	18.7	No	20.5	No	19.0	0.7	2.1	92
U/S Cowper	19.0	19.9	0.9	18.28	not reqd	0.9	22.3	No	25.5	No	22.0	3.0	3.7	89
D/S Waverley	19.6	20.0	0.4	19.52	not reqd	0.4	23.0	No	25.9	No	23.0	3.4	3.5	90
U/S Waverley	20.0	20.5	0.5	20.91	24.91	4.9	26.0	No	29.8	No	25.0	5.0	4.1	87
Bryant	22.0	23.5	1.5	21.21	not reqd	1.5	n/a	n/a	n/a	n/a	25.0	3.0	3.8	n/a
Alma	24.0	25.0	1.0	22.04	not reqd	1.0	25.6	No	29.3	No	26.0	2.0	4.0	91

[1] Lowest Adjacent Grade Within 100 Feet of Bridge
[2] Four feet Freeboard at Structures

Table I-4
Matadero Creek
Risk-Based Design Freeboard

	EXISTING			DESIGN		REQUIRED FREEBOARD				PROPOSED			Deficit[5]	
						FEMA Criteria[2]		SCVWD Criteria[3]						
Location	Sidewalk Elevation	Headwall Elevation	Wall Height Above Sidewalk	WSEL	Specific Energy	Top of Wall	Wall Height Above Sidewalk	Top of Wall	Wall Height Above Sidewalk	Top of Wall	**Wall Height above Sidewalk[4]**	Freeboard	FEMA	District
	(feet)	(NGVD)	(feet)	(NGVD)	(feet)	(NGVD)	(feet)	(NGVD)	(feet)	(NGVD)	(feet)	(feet)	(feet)	(feet)
W. Bayshore	9.8	10.5	0.7	5.71	10.00	not reqd	0.7	7.71	0.7	10.00	3.0	4.29	n/a	(2.29)
D/S Greer	6.2	9.3	3.1	7.90	12.19	11.9	5.7	11.90	5.7	10.00	**3.8**	2.10	1.90	1.90
U/S Greer	6.2	10.0	3.8	8.81	12.27	12.81	6.6	12.81	6.6	11.20	**5.0**	2.39	1.61	1.61
D/S Louis	8.4	10.6	2.2	9.26	11.78	13.26	4.9	13.26	4.9	11.50	2.2	2.24	1.76	1.76
U/S Louis	8.4	11.2	2.8	10.22	12.61	14.22	5.8	14.22	5.8	13.70	**4.3**	3.48	0.52	0.52
D/S Ross	13.2	15.5	2.3	11.21	11.45	15.21	2.0	13.50	2.3	13.80	2.3	2.59	1.41	(0.30)
U/S Ross	13.2	15.5	2.3	12.32	12.06	16.32	3.1	14.73	2.3	16.30	**3.1**	3.98	0.02	(1.57)
D/S Middlefield	16.7	19.0	2.3	14.14	12.63	not reqd	2.3	16.67	2.3	17.50	2.3	3.36	n/a	(0.83)
U/S Middlefield	16.7	19.0	2.3	14.64	11.25	not reqd	2.3	16.89	2.3	18.50	2.3	3.86	n/a	(1.61)
D/S Cowper	19.4	21.8	2.4	16.94	12.19	not reqd	2.4	19.38	2.4	19.00	2.4	2.06	n/a	0.38
U/S Cowper	19.4	21.8	2.4	18.28	12.50	not reqd	2.4	20.78	2.4	22.00	2.4	3.72	n/a	(1.22)
D/S Waverley	21.2	23.4	2.2	19.52	12.68	not reqd	2.2	22.06	2.2	23.00	2.2	3.48	n/a	(0.94)
U/S Waverley	21.2	23.4	2.2	20.91	13.55	24.91	3.7	23.62	2.4	25.00	**3.8**	4.09	(0.09)	(1.38)
U/S SPRR	29.5	29.6	0.1	25.05	13.69	not reqd	0.1	27.79	0.1	29.00	0.1	3.95	n/a	(1.21)
D/S Channel Bend[1]	n/a	n/a	n/a	26.73	14.37	not reqd	n/a	29.60	n/a	n/a	n/a	n/a	n/a	n/a
U/S Channel Bend[1]	n/a	n/a	n/a	26.65	13.08	not reqd	n/a	29 27	n/a	n/a	n/a	n/a	n/a	n/a
D/S Park	27.3	31.5	4.2	26.82	13.27	not reqd	4.2	29.47	4.2	31.50	4.2	4.68	n/a	(2.03)
U/S Park	27.3	31.5	4.2	26.89	13.19	not reqd	4.2	29.53	4.2	31.50	4.2	4.61	n/a	(1.97)
U/S Lambert	29.2	33.3	4.1	28.93	12.49	not reqd	4.1	31.43	4.1	33.26	4.1	4.33	n/a	(1.83)
U/S El Camino	31.0	39.6	8.6	29.74	7.69	not reqd	8.6	31.28	8.6	39.61	8.6	9.87	n/a	(8.33)

[1] Includes Superelevation

[2] Four feet Freeboard at Structures

[3] Design Water Surface + maximum of [1 foot or 0.2 x Specific Energy]

[4] Bold numbers indicate change from existing.

[5] Relative to Respective Standard Freeboard Criteria

APPENDIX J
BEST MANAGEMENT PRACTICES FOR CONSTRUCTION

The preferred project and construction procedures have been described in detail in Chapter 7 and are shown on the plates located at the end of this report. The California construction Best Management Practices (BMPs) would be implemented during all construction activities. The following are some of the BMPs pertinent to this project (Stormwater Quality Task Force, March 1993).

BMP FOR SCHEDULING

The BMP for scheduling includes the following guidelines:

- Major grading operations would be scheduled during dry months.
- Sufficient time would be provided before rainfall begins to stabilize the soil with vegetation.
- The site would be stabilized year-round from erosion and sediment buildup.
- Only portions of the site would be disturbed at any one time, and grading would be completed immediately. Disturbed portions of the site would be stabilized prior to grading the next portions.
- As the work progresses, cut and fill slopes would be revegetated wherever feasible and appropriate.
- Trenching would be scheduled so that most open portions of the trench are filled before new trenching is begun.

BMP FOR PRESERVING EXISTING VEGETATION

The BMP for preserving existing vegetation at the site includes the following guidelines:

- Existing vegetation to be preserved would be flagged.
- The root system of trees to be preserved would be staked off prior to construction.
- The limits of grading or disturbance would be clearly marked at all times.
- Locate construction traffic routes and spoil piles away from existing vegetation.

BMP FOR DUST CONTROL

The BMP for minimizing dust occurrence at the site includes the following guidelines:

- Key access points would be identified and stabilized prior to commencement of construction.
- Where possible, construction traffic would be directed to stabilized roadways.
- Watering of dust prone areas would be frequent, but not excessive.
- The number and activity of vehicles on a site at any given time would be controlled.
- Haul trucks transporting materials would be provided with covers.
- Sediment deposited on paved roads would be rapidly cleaned up.

BMP FOR CONSTRUCTION ROAD STABILIZATION

The BMP for stabilizing construction roads includes the following guidelines:

- Temporary access roads would be stabilized immediately after grading and maintained to prevent erosion and control dust.
- Gravel would be used for temporary roadways during rainy seasons and/or on slopes greater than 5 percent.
- The roadways would be carefully graded to drain transversely.

BMP FOR STABILIZED CONSTRUCTION ENTRANCE

The BMP for stabilizing temporary access roads includes the following guidelines:

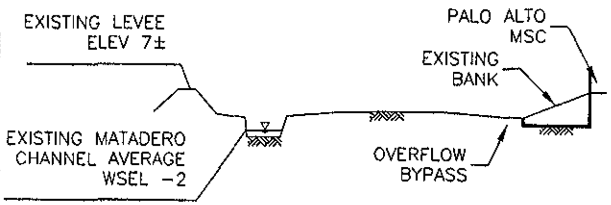
- Access roads would be constructed on level ground where possible.
- The minimum depth of rock would be as recommended by a soils engineer.
- The minimum turning radii for entrance or exit to and from the temporary access road would follow the District's maintenance guidelines.

BMP FOR TEMPORARY DRAINS AND SWALES

The BMP for temporary drains and swales includes the following guidelines:

- Temporary drainage swales would be sized using local drainage design criteria. They would be designed so as no to adversely impact upstream or downstream properties.
- At a minimum, the drain/swale would conform to pre-development drainage patterns and capacities.
- The drain/swale would be constructed with an uninterrupted, positive grade to a stabilized outlet.
- Energy dissipation measures will be provided if the flow out of the drain/swale can reach an erosive velocity.
- The drain/swale would be inspected weekly and after each rain for erosion or sediment buildup.
- If there is a possibility for significant erosion to occur, the drainage swale would be stabilized using vegetation, chemical treatment, rock riprap, matting, or other physical means of stabilization.

PLATES



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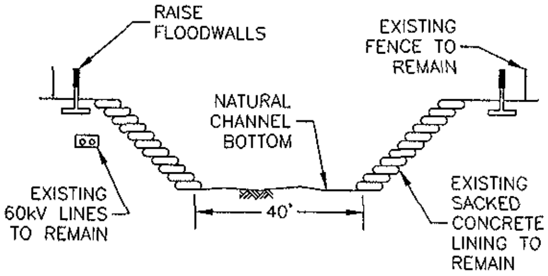
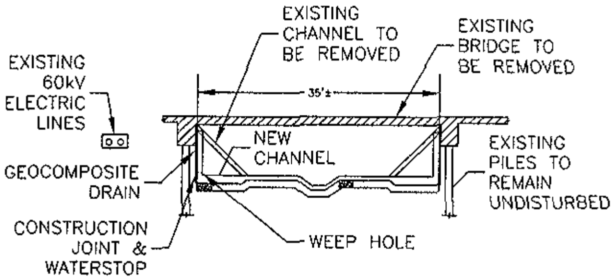
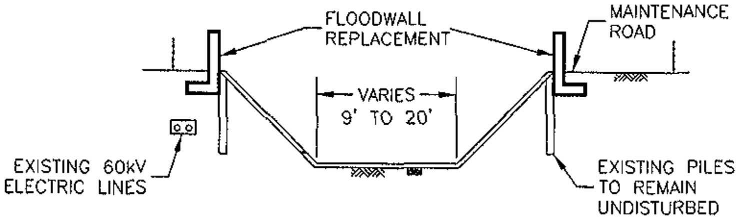
PAFB TO EAST BAYSHORE ROAD
STA 84+41 TO 92+16
(BYPASS 16+00 to 1+00)



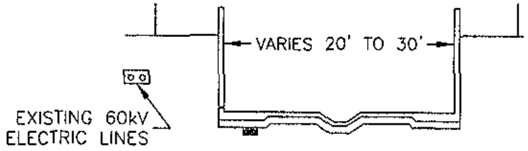
TYPICAL SECTION
WEST BAYSHORE ROAD TO GREER ROAD
STA 95+68 TO 107+87



TYPICAL SECTION
LOUIS ROAD BRIDGE
MODIFICATIONS
STA 119+21 TO 119+83



TYPICAL SECTION
GREER ROAD TO ALMA STREET
STA 108+40 TO 175+44



TYPICAL SECTION
SPRR TO EL CAMINO REAL
(NO MODIFICATIONS)
STA 176+98 TO 197+80

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REV	DESCRIPTION	DATE	APPR

REFERENCE INFORMATION AND NOTES
1. National Geodetic Vertical Datum of 1929 (NGVD29)
2. Left and Right Bank are designated looking upstream
3. Preliminary drawing, not for construction.

Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS
100 N. WINCHESTER BLVD, STE. 200
SANTA CLARA, CA 95050
(408) 246-4848

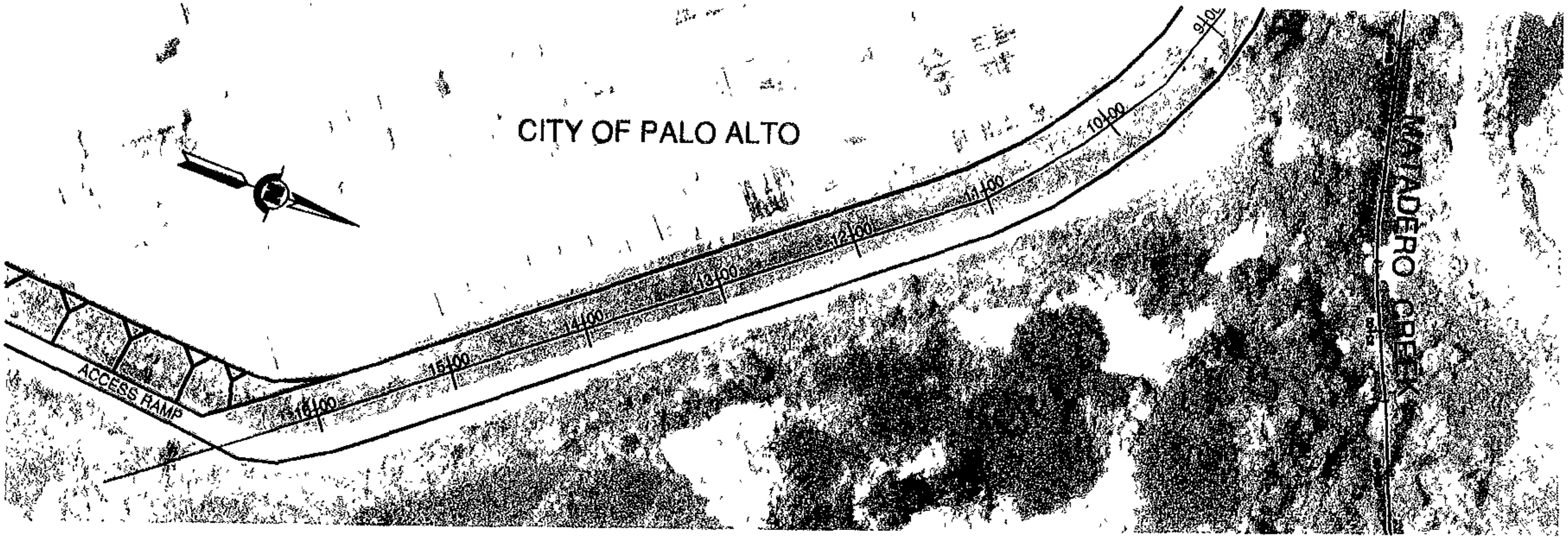
CHARLES D. ANDERSON
No. 43776
Exp. 6-30-05

DATE
9/27/01
DESIGN
DRAWN
V. PARKS
CHECKED

Santa Clara Valley Water District
ENGINEERING CERTIFICATION
ENGINEERING APPROVAL

MATADERO CREEK
PALO ALTO FLOOD BASIN TO EL CAMINO REAL
TYPICAL SECTIONS

SCALE
NTS
SHEET
1
OF



PLAN
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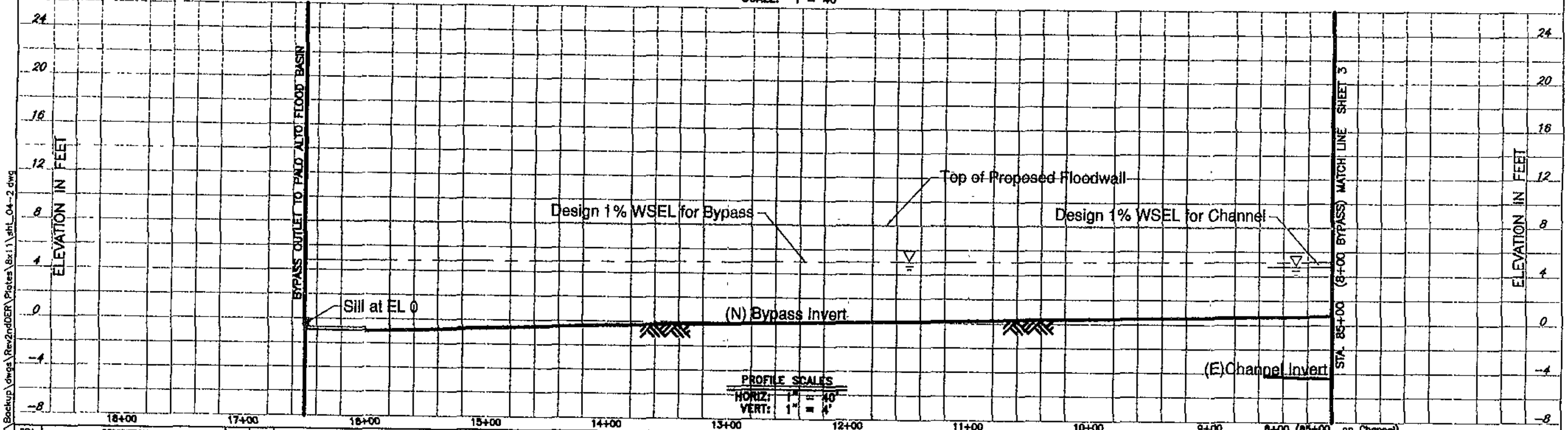
ELEVATION IN FEET
24
20
16
12
8
4
0
-4
-8
BYPASS OUTLET TO PALO ALTO FLOOD BASIN
Sill at EL 0
Design 1% WSEL for Bypass
Top of Proposed Floodwall
(N) Bypass Invert
Design 1% WSEL for Channel
(E)Channel Invert
STA. 85+00 (8+00 BYPASS) MATCH LINE SHEET 3
18+00
17+00
16+00
15+00
14+00
13+00
12+00
11+00
10+00
9+00
8+00 (85+00 on Channel)

PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

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CHARLES D. ANDERSON
No. 43775
Exp. 6-30-05

DATE 9/27/01
DESIGN
DRAWN V. PARKS
CHECKED

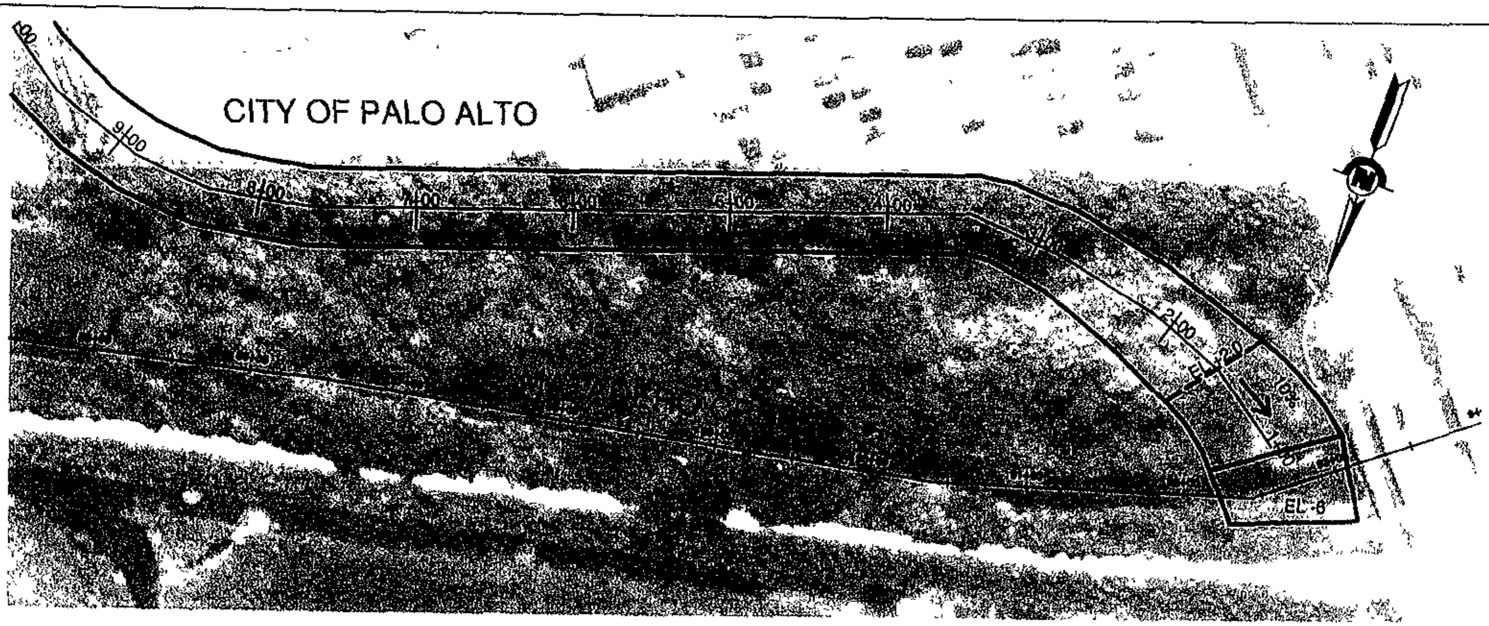
Santa Clara Valley Water District

ENGINEERING CERTIFICATION
ENGINEERING APPROVAL

MATADERO CREEK
PALO ALTO FLOOD BASIN TO BAYSHORE FREEWAY
PLAN AND PROFILE

SCALE
H: 1"=40'
V: 1"=4'

SHEET
2
OF



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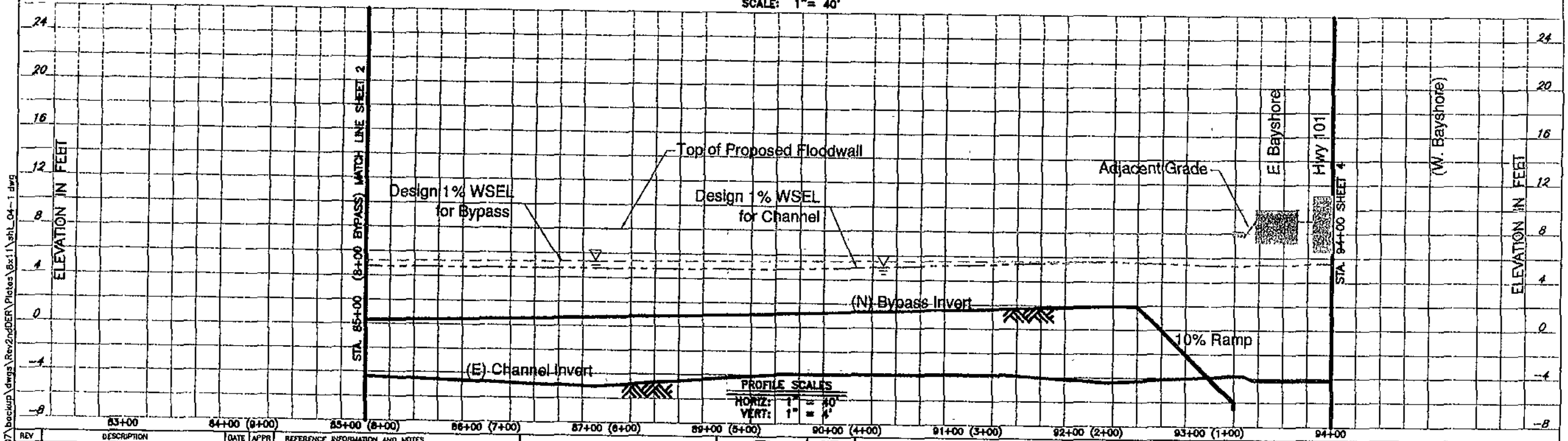

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No. 43779
Exp. 6-30-05

DATE 9/27/01
DESIGN
DRAWN V. PARKS
CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION
ENGINEERING APPROVAL

MATADERO CREEK
PALO ALTO FLOOD BASIN TO BAYSHORE FREEWAY
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'
SHEET 3
OF

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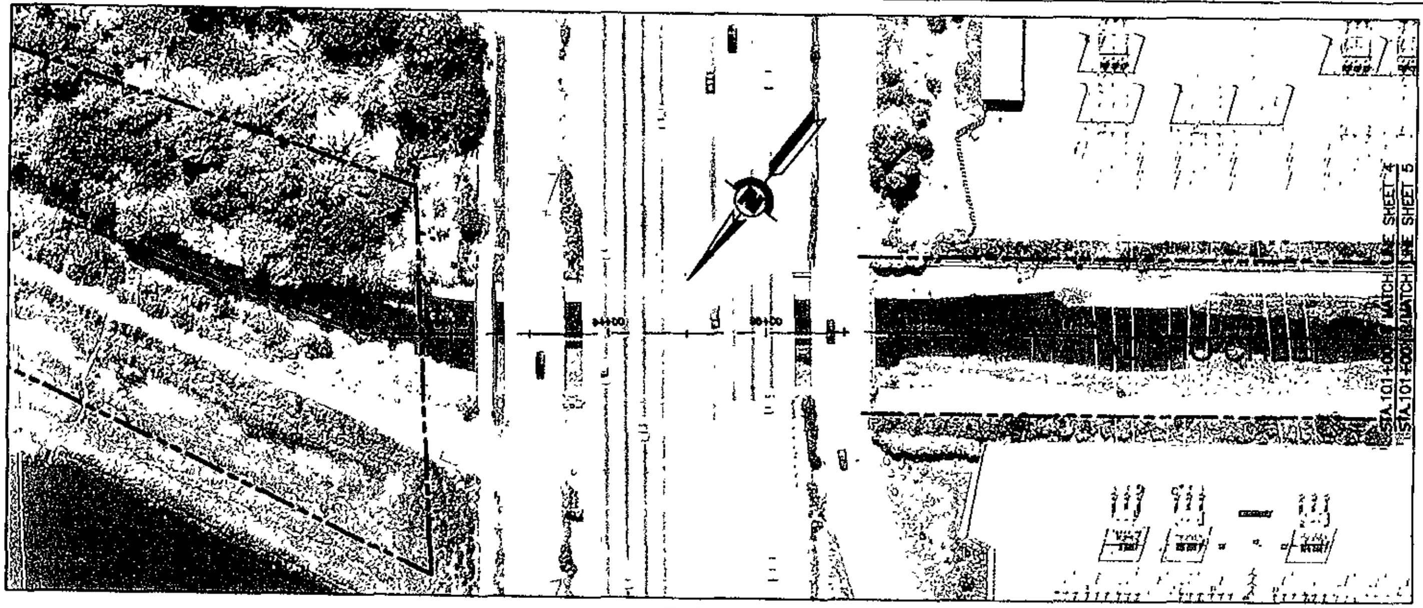
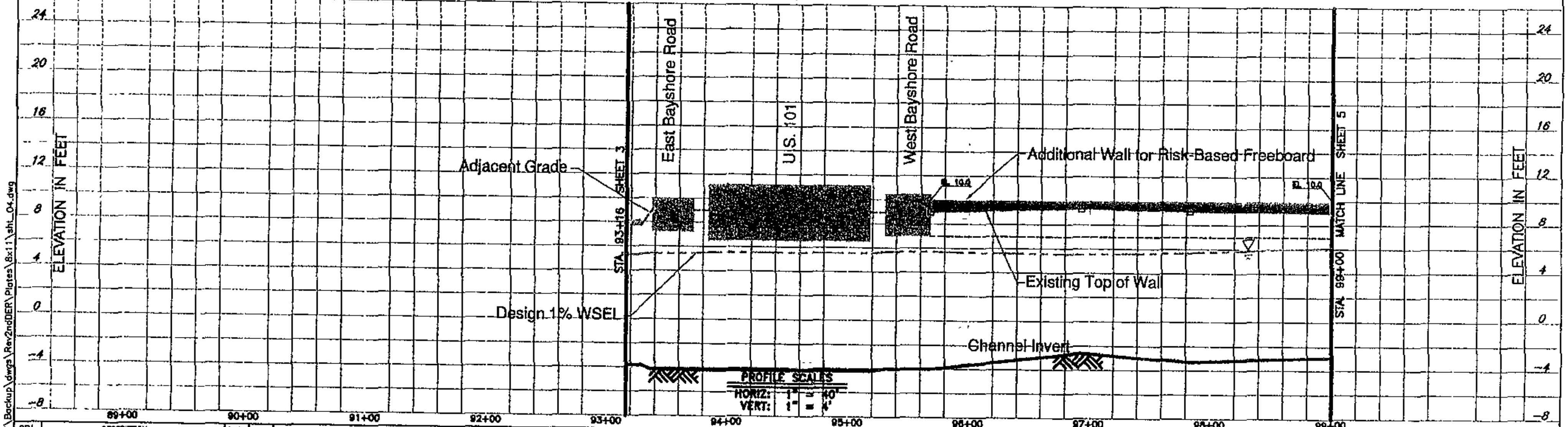


PLAN
SCALE: 1" = 40'



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No. 43778
Exp. 6-30-05

DATE 9/27/01
DESIGN
DRAWN V. PARKS
CHECKED

Santa Clara Valley Water District

ENGINEERING CERTIFICATION
ENGINEERING APPROVAL

MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'
SHEET 4 OF

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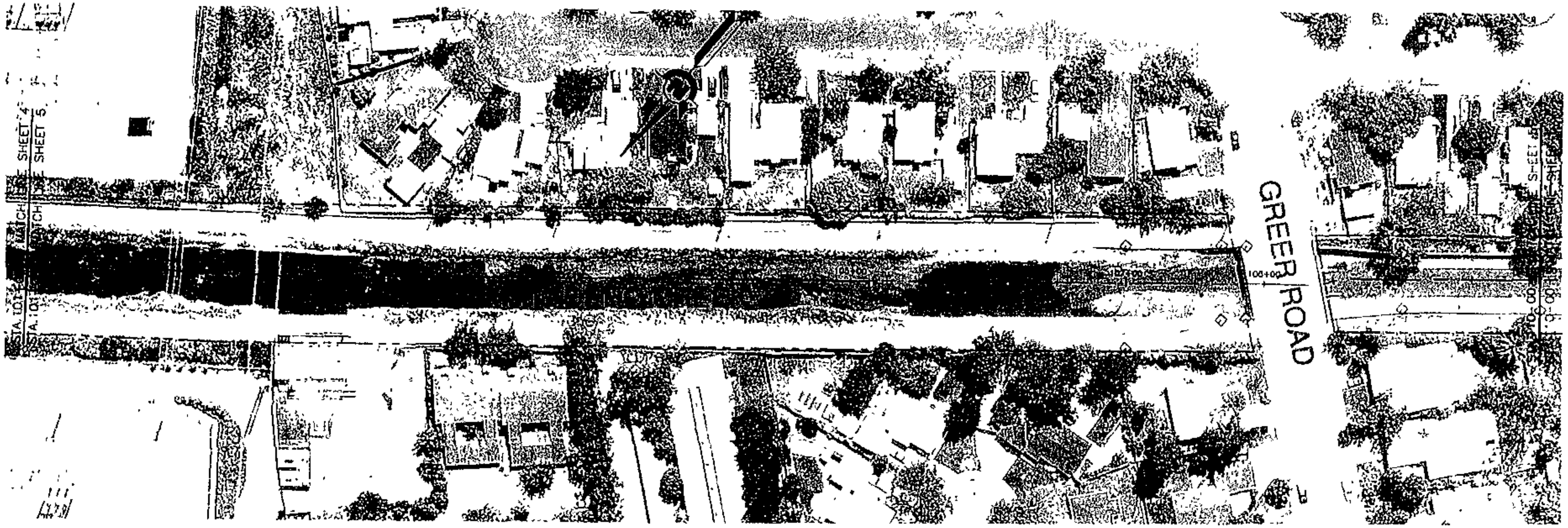

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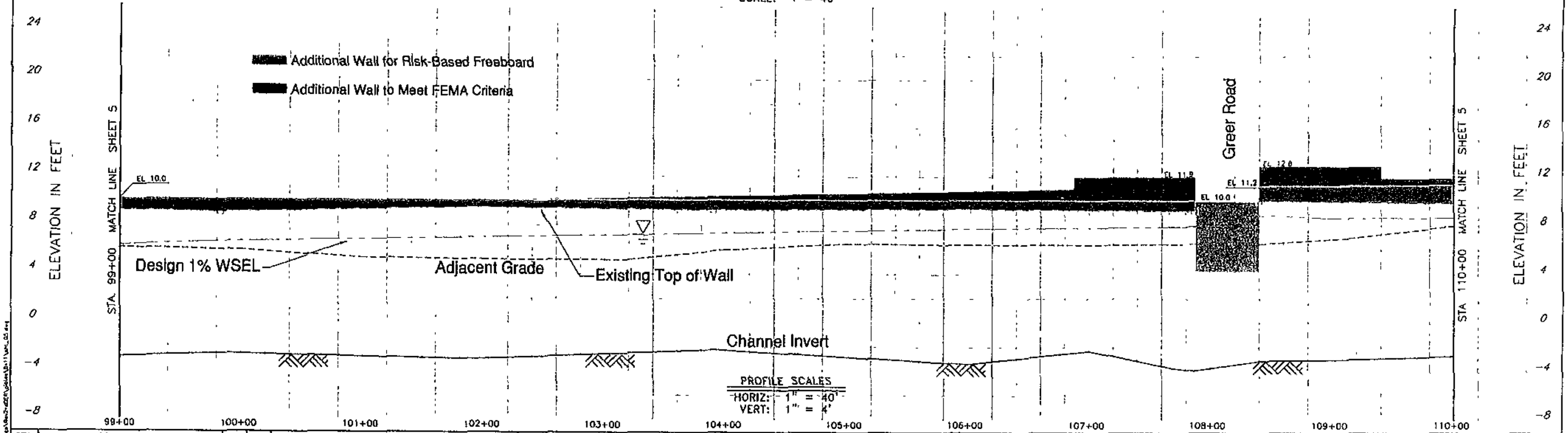
SCALE: 1" = 40'



PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

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Schaaf & Wheeler
CONSULTING CIVIL ENGINEERS
100 N. WINCHESTER BLVD, STE. 200
SANTA CLARA, CA 95050
(408) 246-4848

No. 43776
Exp 6-30-05

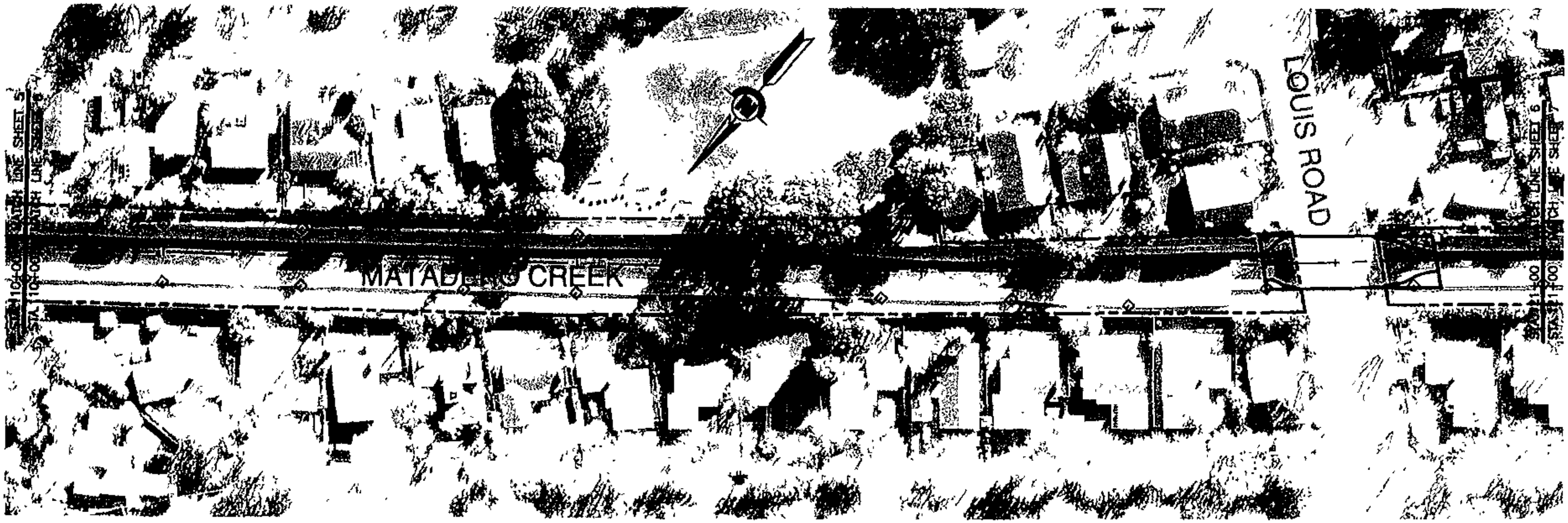
DATE 9/27/01
DESIGN
DRAWN V PARKS
CHECKED

Santa Clara Valley Water District

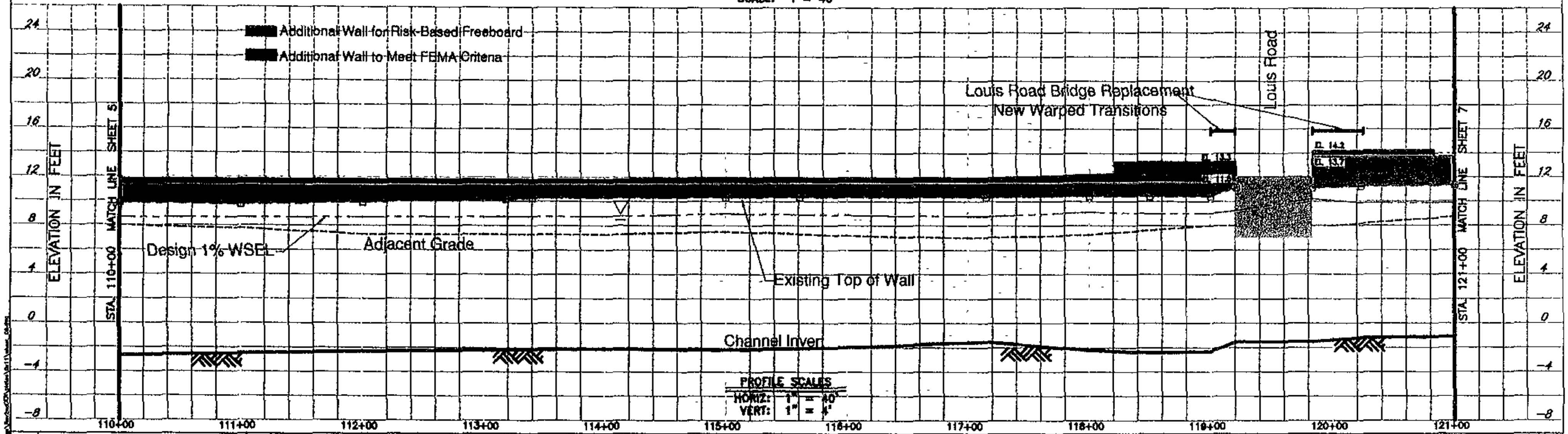
ENGINEERING CERTIFICATION
ENGINEERING APPROVAL

MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H 1"=40' V. 1"=4'
SHEET 5 OF


LOUIS ROAD
MATADERO CREEK
STA. 110+00 MATCH LINE SHEET 5
STA. 121+00 MATCH LINE SHEET 7

PLAN
SCALE: 1" = 40'



REV	DESCRIPTION	DATE	APPR

REFERENCE INFORMATION AND NOTES
1. National Geodetic Vertical Datum of 1929 (NGVD29)
2. Left and Right Bank are designated looking upstream
3. Preliminary drawing, not for construction.

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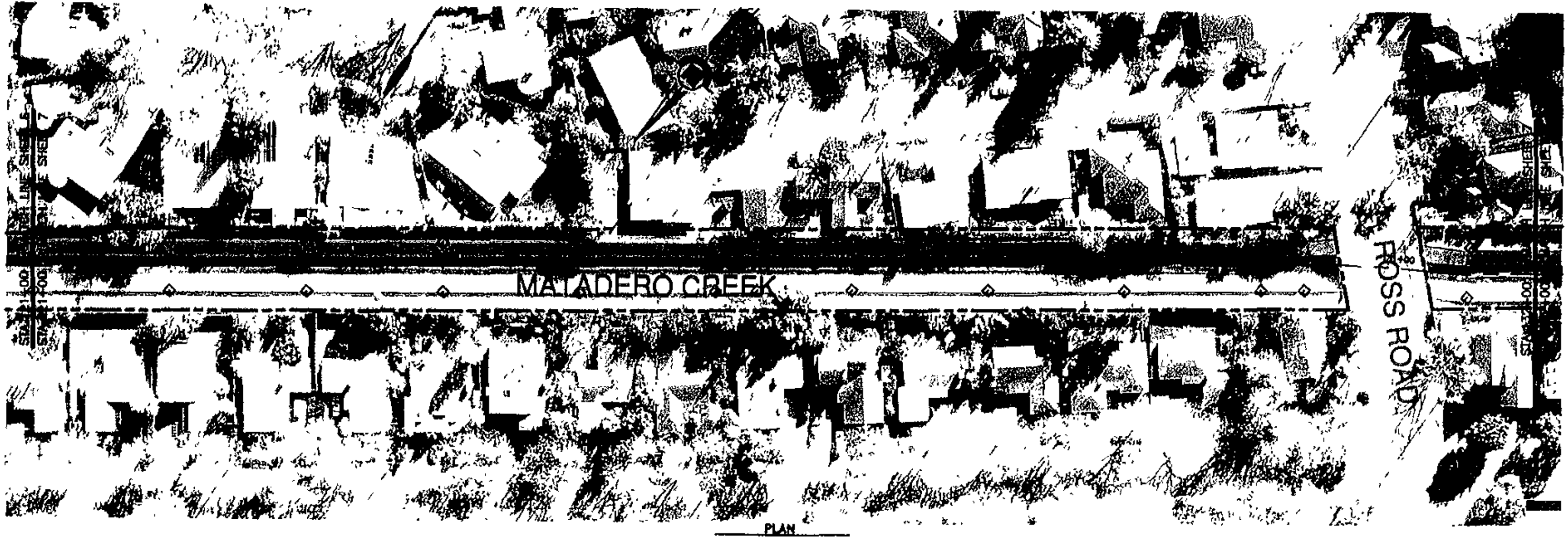
ENGINEERING APPROVAL

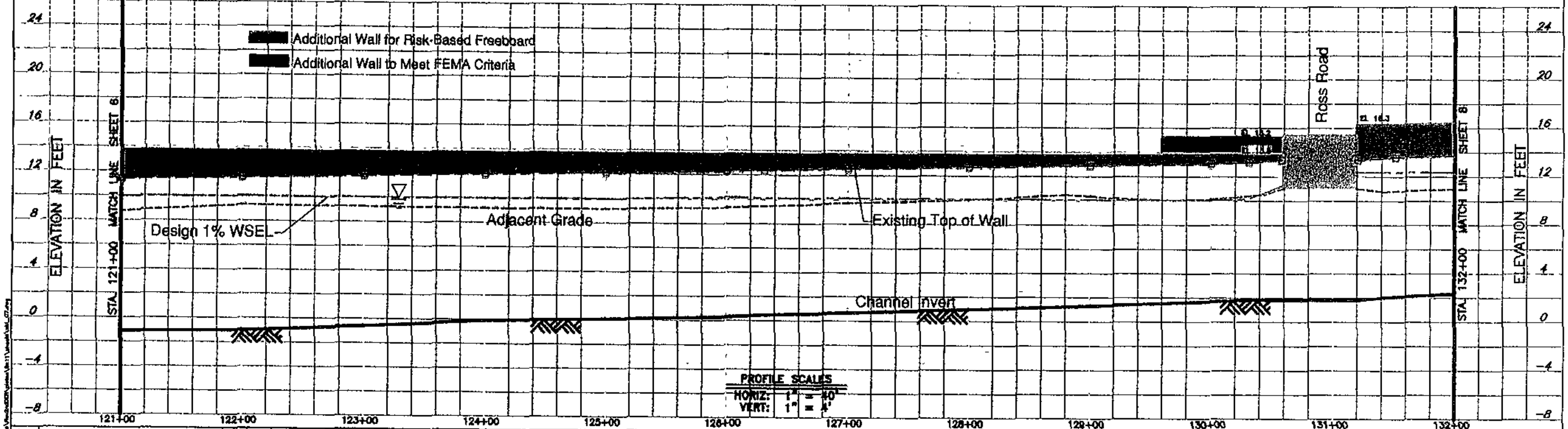
MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE
H: 1"=40'
V: 1"=4'

SHEET
6
OF



PLAN
SCALE: 1" = 40'



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Charles D. Anderson
No. 43778
Exp. 6-30-05

DATE 9/27/01
DESIGN
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Santa Clara Valley Water District

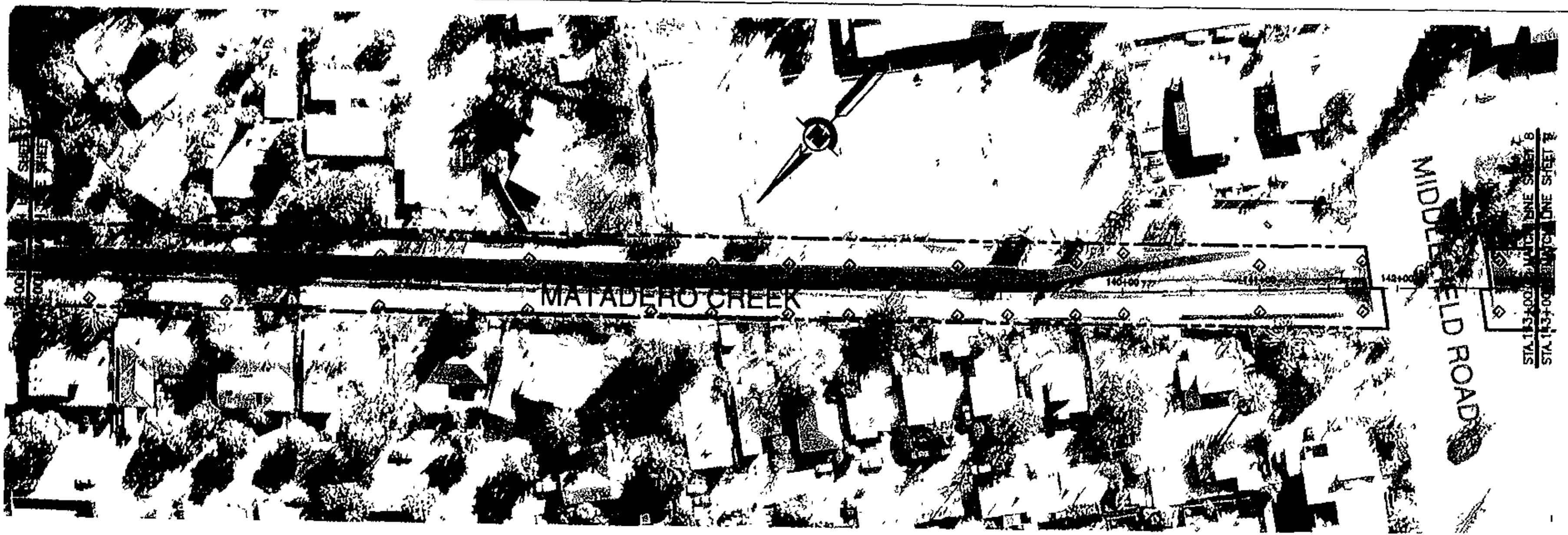
ENGINEERING CERTIFICATION

ENGINEERING APPROVAL

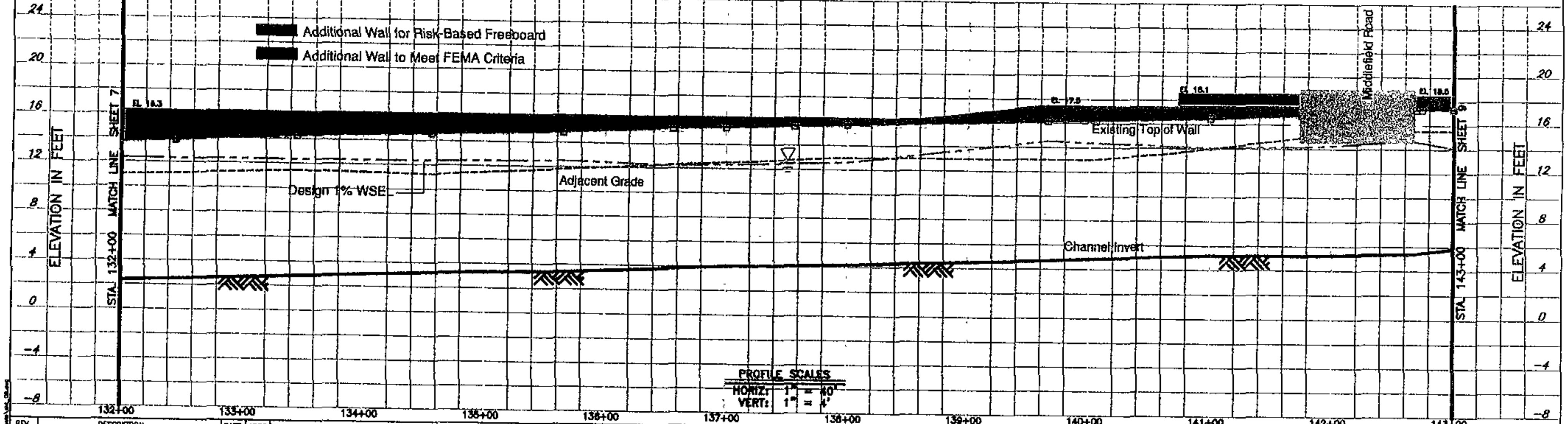
MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'

SHEET 7 OF



PLAN
SCALE: 1" = 40'



PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

REV	DESCRIPTION	DATE	APPR

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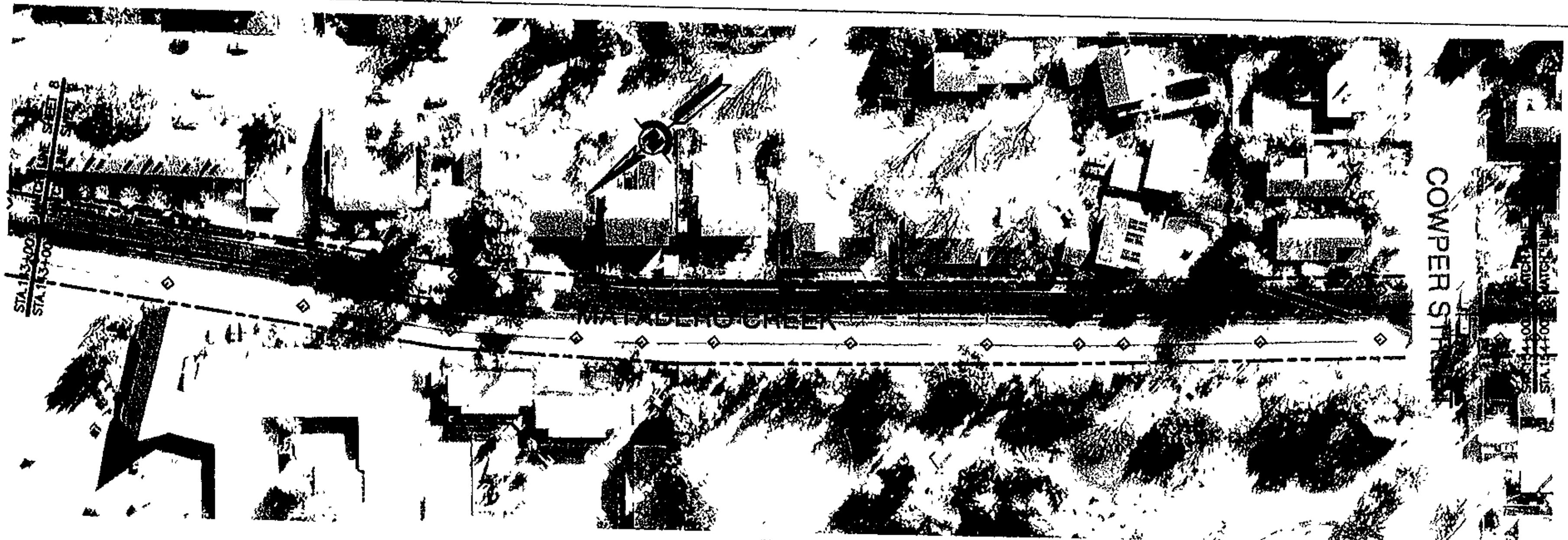
Santa Clara Valley Water District

ENGINEERING CERTIFICATION

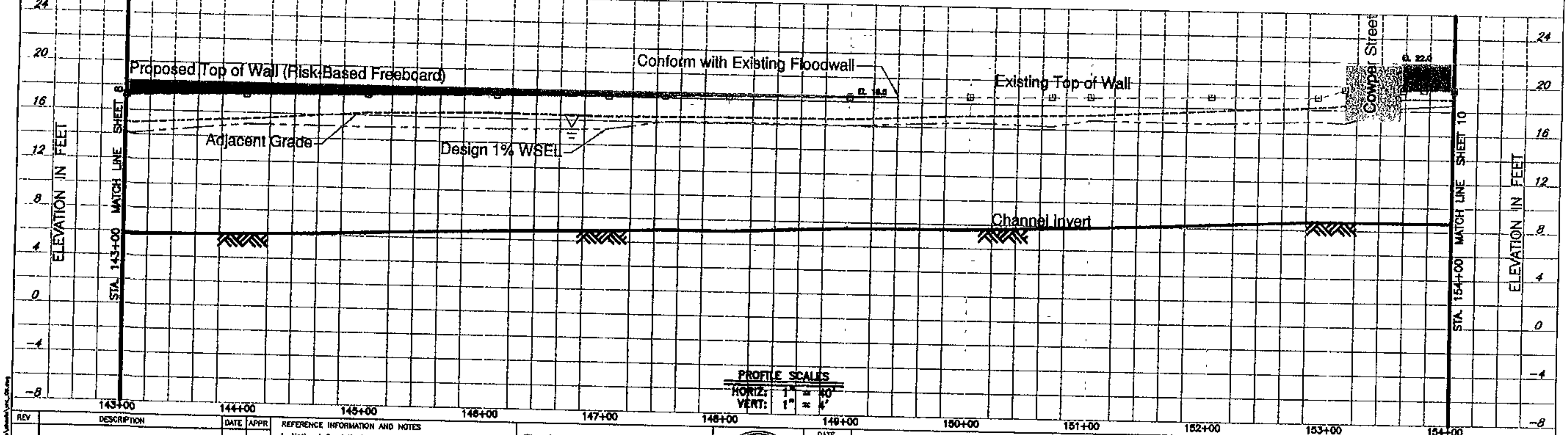
ENGINEERING APPROVAL

MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'
SHEET 8 OF


STA. 143+00 MATCH LINE SHEET 8
MATADERO CREEK
COWPER ST.
STA. 154+00 MATCH LINE SHEET 10

PLAN
SCALE: 1" = 40'



PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

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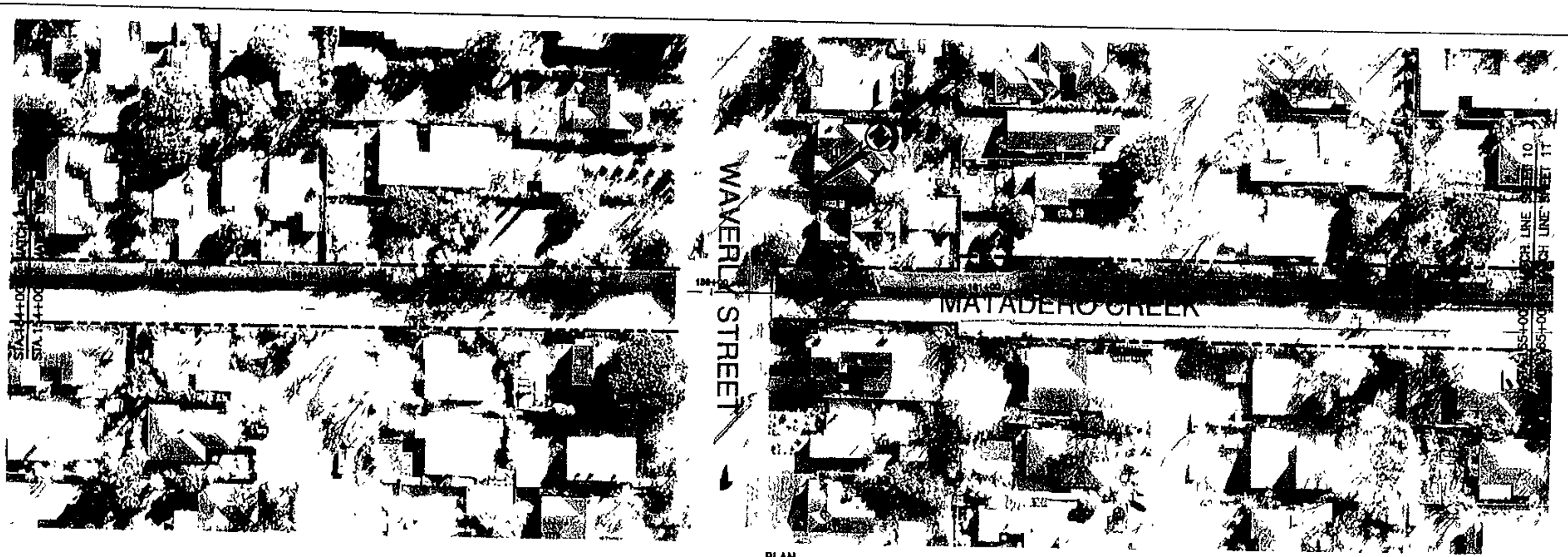
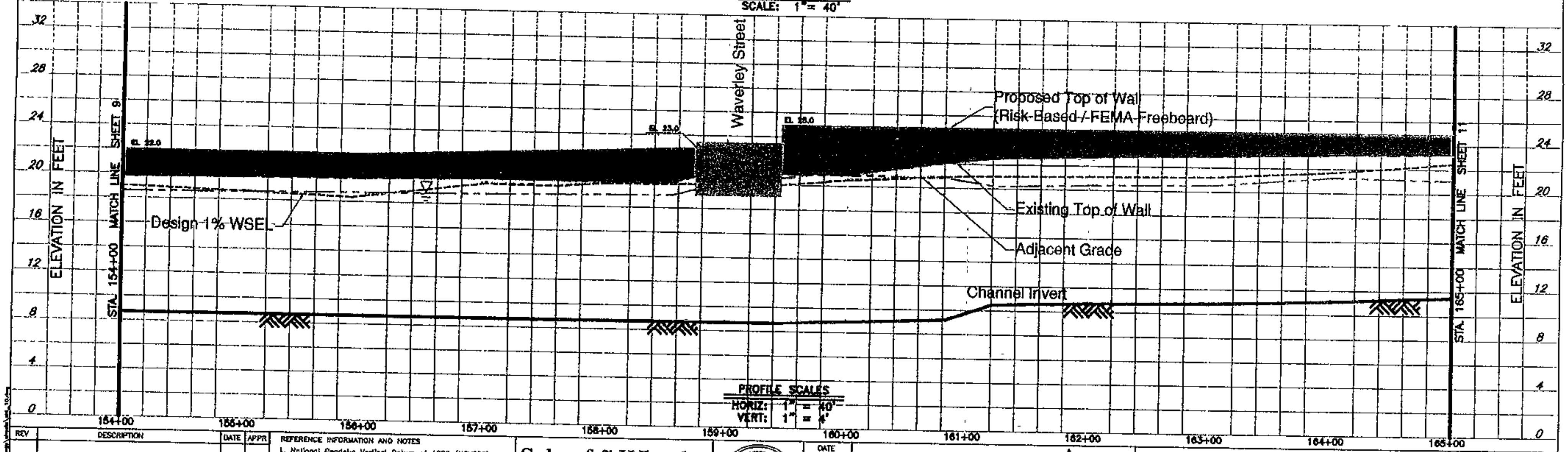
MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'
SHEET 9 OF


STA. 154+00 MATCH LINE SHEET 9
WAVERLY STREET
MATADERO CREEK
STA. 165+00 MATCH LINE SHEET 11
MATCH LINE SHEET 10

PLAN
SCALE: 1" = 40'



PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

REV	DESCRIPTION	DATE	APPR

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DATE 9/27/01
DESIGN
DRAWN V PARKS
CHECKED

Santa Clara Valley Water District

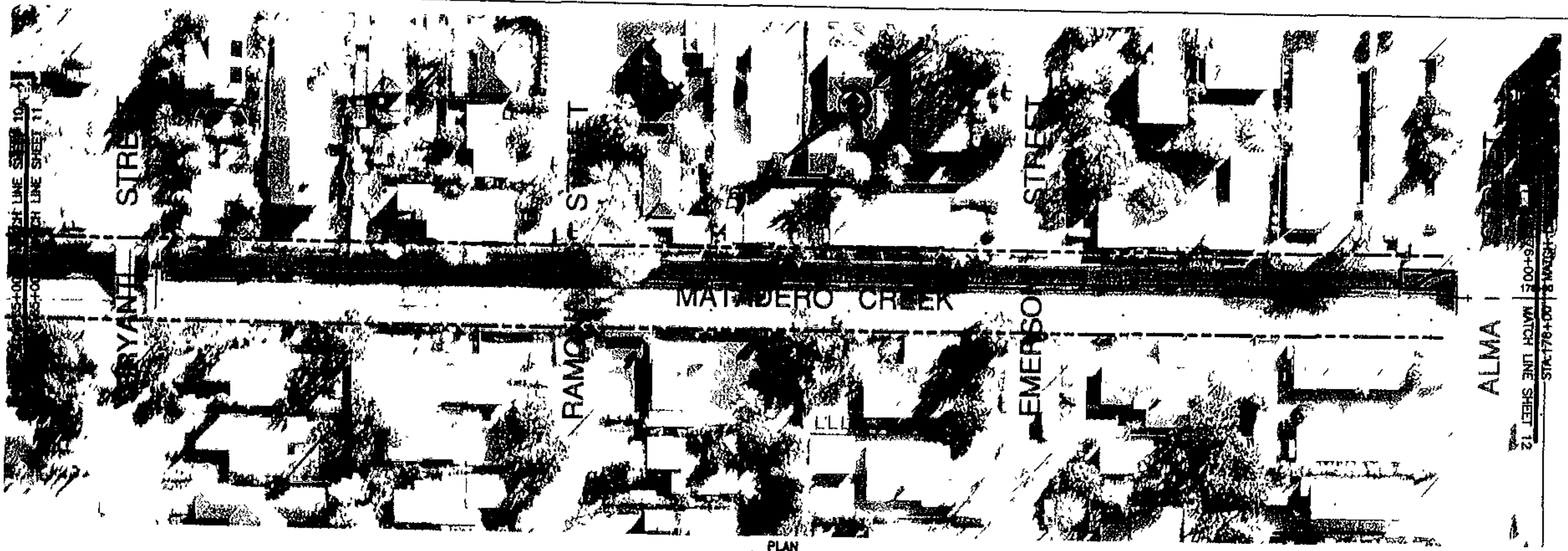
ENGINEERING CERTIFICATION

ENGINEERING APPROVAL

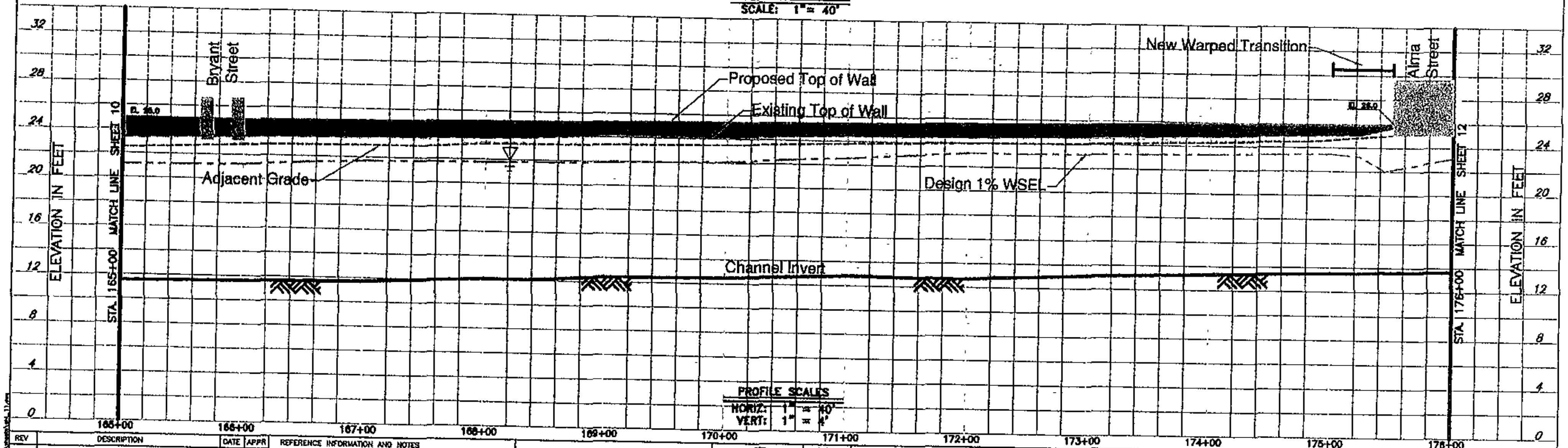
MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE
H: 1"=40'
V: 1"=4'

SHEET
10
OF



PLAN
SCALE: 1" = 40'



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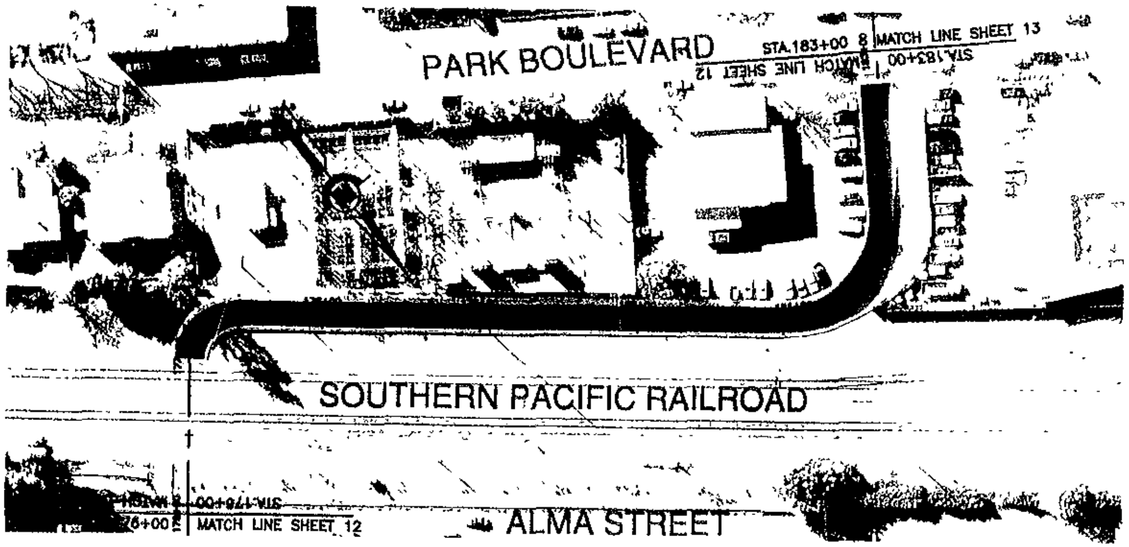
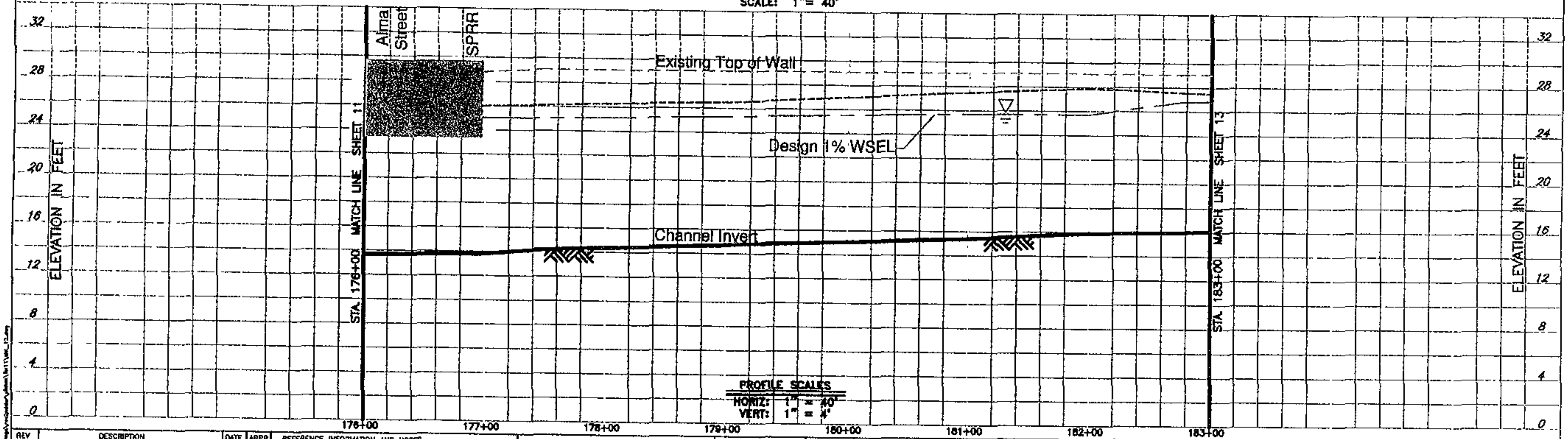
ENGINEERING APPROVAL

MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'
SHEET 11 OF


PARK BOULEVARD
STA.183+00 MATCH LINE SHEET 13
SOUTHERN PACIFIC RAILROAD
ALMA STREET
STA.176+00 MATCH LINE SHEET 12

PLAN
SCALE: 1" = 40'



PROFILE SCALES
HORIZ: 1" = 40'
VERT: 1" = 4'

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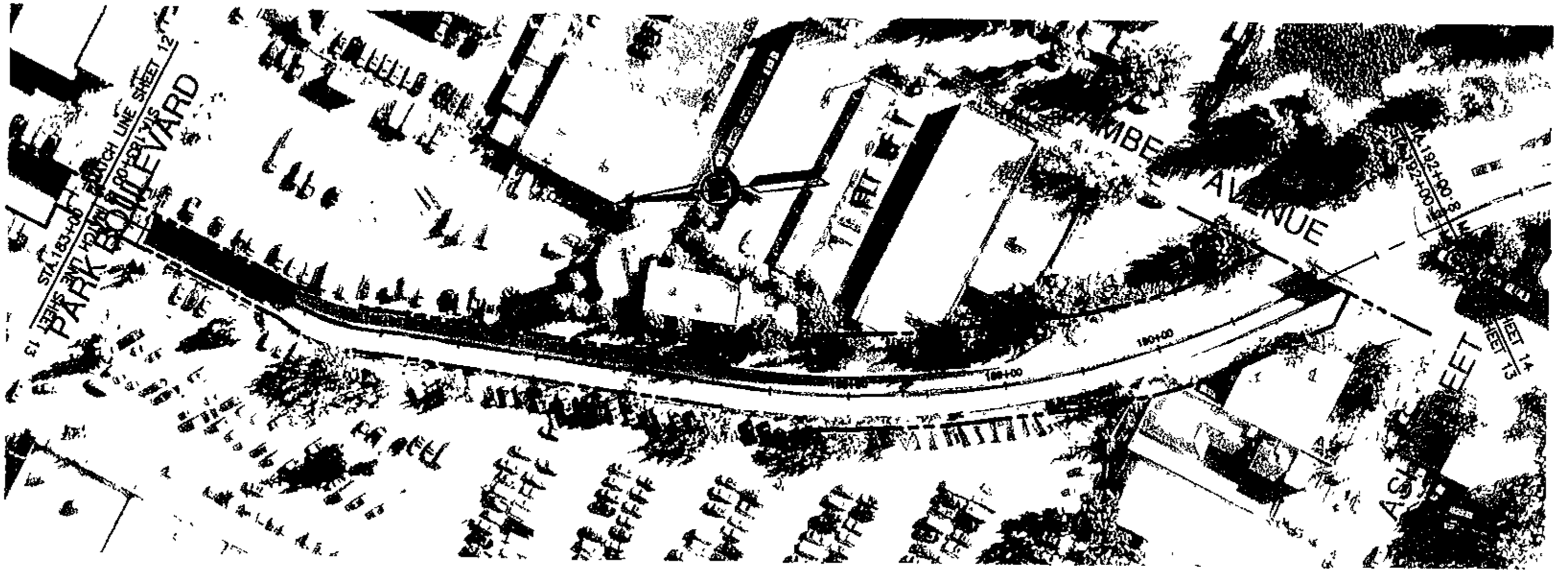
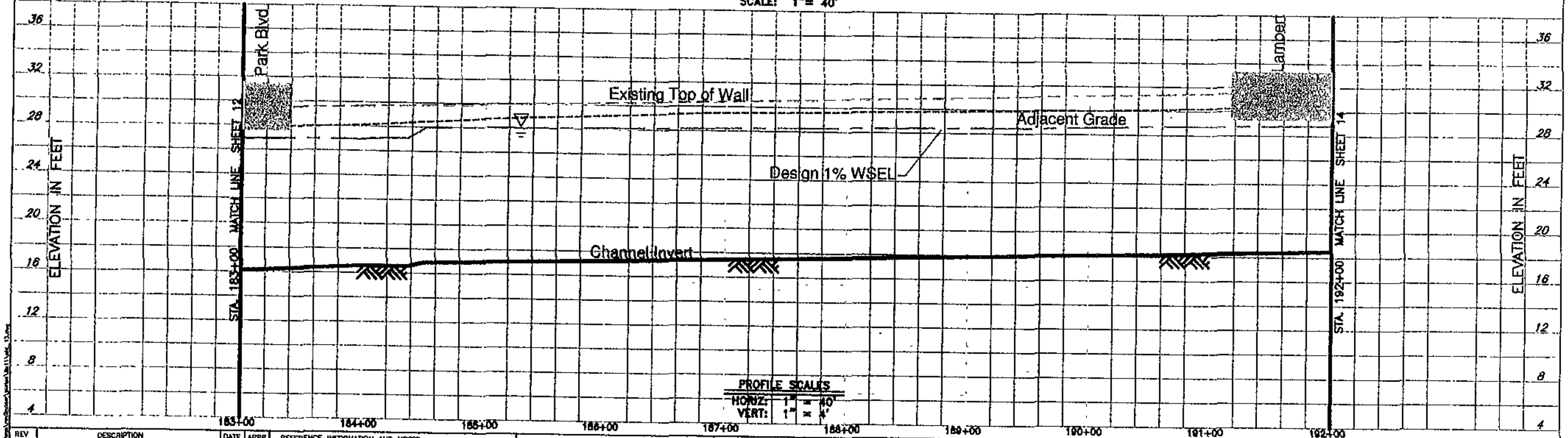
MATADERO CREEK
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE
H: 1"=40'
V: 1"=4'
SHEET
12
OF



PLAN
SCALE: 1"= 40'



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VERT: 1" = 4'

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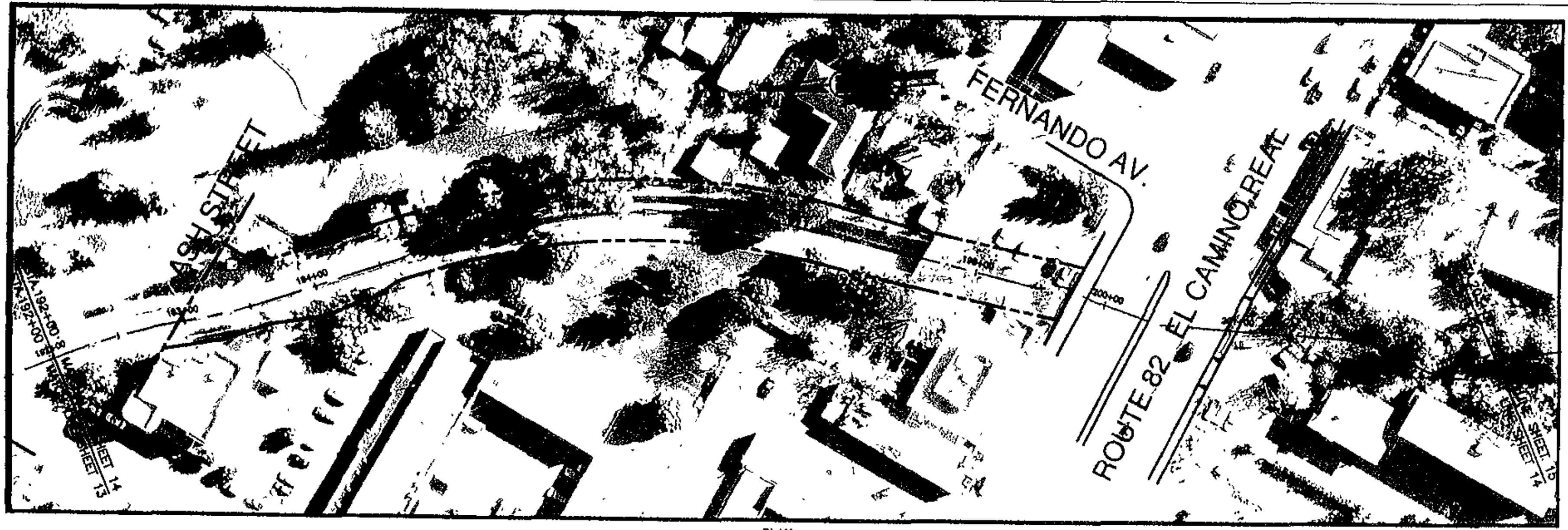
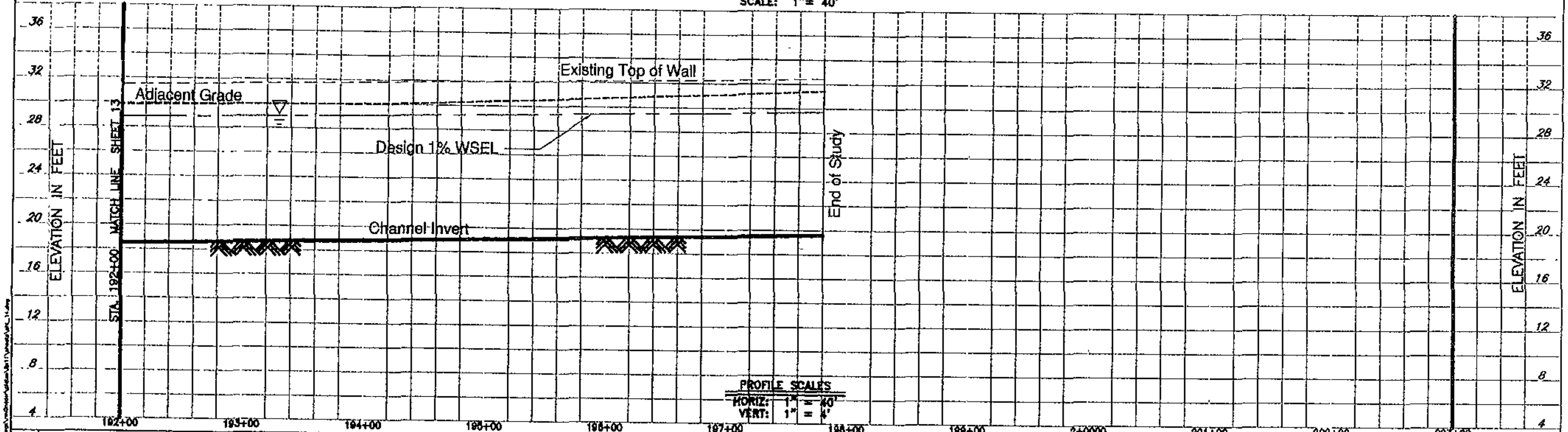
BAYSHORE FREEWAY TO EL CAMINO REAL
PLAN AND PROFILE

SCALE
H: 1"=40'
V: 1"=4'

SHEET
13
OF



PLAN
SCALE: 1" = 40'



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ENGINEERING CERTIFICATION

ENGINEERING APPROVAL

MATADERO CREEK

BAYSHORE FREEWAY TO EL CAMINO REAL

PLAN AND PROFILE

SCALE H: 1"=40' V: 1"=4'

SHEET 14 OF